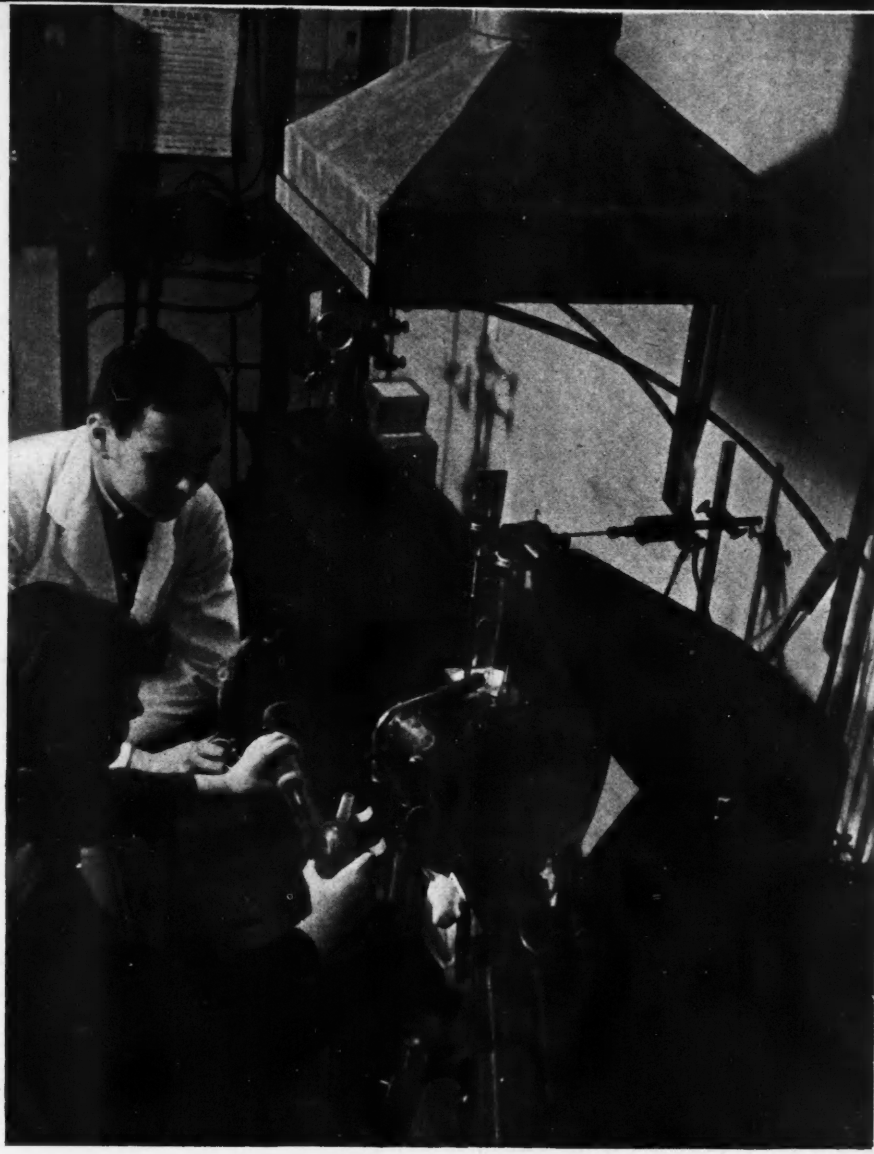
DISCOVERY



PAPER ECONOMY
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DISCOVERY

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The Progress of Science

A MONTHLY NOTEBOOK COMPILED UNDER THE DIRECTION OF DAVID S. EVANS

One Use for Meteors

METEORS, popularly known as "shooting stars" are really small stony or metallic objects which enter the earth's atmosphere and become luminous by reason of their swift passage through the air. Nothing could be more unlike a star. A star is a globe of hot gas hundreds of thousands or millions of miles in diameter, shining by its own light and heat, and even its coldest outer layers are at least at a temperature of three or four thousand degrees. A meteor, fortunately for us, is a small body, rarely more than a matter of inches in diameter, which gains a few seconds' luminosity in its contact with our air before disintegrating completely.

A few meteors reach the earth and can be studied. All contain a certain proportion of the metal, iron, but two classes are distinguished, the stony and the iron. Some which have reached the earth have done widespread damage. The Great Siberian Meteorite which fell in the early part of the present century laid waste a huge area of the fortunately uninhabited regions of Siberia. In Arizona there is a huge crater, reminiscent of a small volcano, believed to have been caused by the impact of a meteorite in the distant past. Masses of meteoric iron which presumably fell before recorded history have been found in various parts of the world, and one collected some years ago in North America was actually being used as an anvil in a blacksmith's shop. This particular specimen was a large irregular ring of iron, the hole in the middle measuring a couple of feet across.

However, such specimens are very rare, and most meteors which are consumed before reaching the earth must be very small, and perhaps almost microscopic in size. The observation of the streaks of light which they produce lasting perhaps less than a second is one of the favourite fields for amateur astronomers, and one in which they can do extremely valuable work. It requires no apparatus; only an infinite patience, a first-class knowledge of all the visible stars, a faculty of quick and accurate observation and an ability to resist the frost of a clear winter's night. What the meteor observer does is to watch the sky and to note down the path of each meteor which he sees and the time of observation. In the moment of the meteor's appearance the expert observer can estimate the direction of the beginning and end of the visible track by noting the relation of these points to the nearby stars. By combining these observations of the directions in which the beginning and ending of the meteor track are seen with similar observations by a second observer placed perhaps fifty miles away it is possible to fix the actual track of the meteor in space, and to determine its height above the earth (Fig. 1).

From the astronomical point of view the interest of meteors lies in their origin. A considerable number of meteors occur in showers when a large number of trails may be seen apparently radiating from a point in the sky. In reality the tracks of these shower meteors are roughly parallel, and their apparent point of origin is the "vanishing point" of the perspective view of these parallel lines which we have from the earth. Certain of these meteor showers have been accounted for on the theory that they are the débris of comets which have disintegrated. Comets are bodies of very small size and mass by astronomical standards, their brilliance being due to the plume of luminous gas which they acquire on approaching the sun. Many of these comets move in orbits about the sun, and if they disintegrate the particles will continue to follow the same track through space. Thus when the earth crosses such a track particles enter the atmosphere and are seen as meteors.

On the other hand there may be meteors which come from outside the solar system, and would be, if they were not consumed by entanglement with the earth's atmosphere, no more than passing visitors to the solar system. This is a point of considerable controversy and the matter cannot be said to be settled. On balance the weight of evidence is against the occurrence of these high-speed meteors, but it is difficult to be certain.

However, since meteors shine only by reason of their passage through the earth's atmosphere, the possibility arises of finding out more about the earth's atmosphere by studying the way in which the meteors behave when they

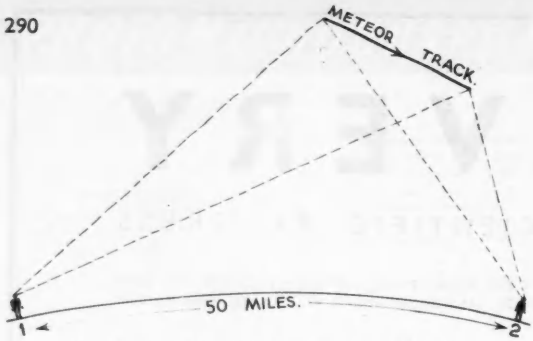

FIG. 1.—Principle of determining the track of a meteor by observations from two positions.

enter it. The condition of the upper layers of the earth's atmosphere is of considerable interest to meteorologists. It is thought that information about the higher levels may throw considerable light on the causes of the weather which we experience down below. The influence of the sun's radiation, especially in the band of the shorter wavelengths, must play a considerable part in determining the state of the atmosphere, and there is also a close relationship between the conditions of the upper atmosphere and the circumstances of propagation of radio waves.

Direct measurements with high-altitude un-manned balloons reach no further than thirty kilometres above the earth. Further measurements must be made indirectly. Studies of the reflection of gunfire noises suggest that the temperature of the atmosphere rises to a height of fifty or sixty kilometres above the stratosphere, and evidence from the oscillations of the earth's atmosphere then indicates a fall in temperature. From studies of the aurora borealis which occurs at very high altitudes it has been concluded that the temperature at 100 kilometres may be as much as seventy degrees centigrade.

Dr. Fred L. Whipple, writing in the Reviews of Modern Physics, has studied the results of meteor observations

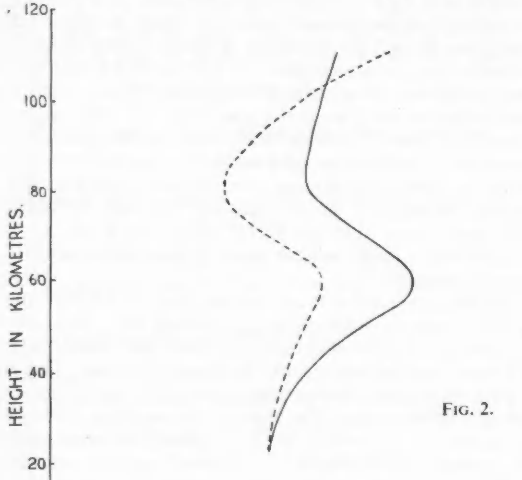

FIG. 2.

Reproduced from Jeans' "Stars in their Courses" (C.U.P.)

FIG. 3.—A Meteor Trail.

obtained photographically at Harvard and a second nearby station. The wide-angle cameras had rotating shutters which interrupted the light twenty times a second. A meteor trail as recorded was therefore broken into a series of short streaks separated by gaps. The spacing of these gaps enabled the speed and deceleration of the meteor to be determined, and the comparison of the records of the two cameras gave the actual track in space as before. The reduction of the observations was an exceedingly complex business. Allowance had to be made for the loss of mass of the meteor as it steadily disintegrated in its passage through the air. The resistance of the air (which of course depends on the density) had to be found and many other corrections applied.

The results of such investigations are naturally not endowed with great accuracy, and it is not surprising that the very varied indirect methods, which are all that are available for estimating the temperature of the upper atmosphere, are not fully concordant. Dr. Whipple's results may be represented by the full curve of Fig. 2. The temperatures which he found are rather higher than those (dotted curve) indicated by previous researches.

The Cyclotron

SOON after the last war it was realised that it was possible to split up the nuclei of atoms by bombarding them with

particles moving at high speed. The nucleus is the central heavy part of an atom bearing a positive charge. Round it move a number of electrons which have negative electric charges, the number being normally just sufficient to balance the positive charge on the nucleus. The number and character of these electrons determine the chemical behaviour of the atom, for they provide the electrical linkages with other atoms which enable chemical combinations to be formed. If a change in the structure of the nucleus can be brought about, say by removing a portion so that the remainder has a different positive charge, then this remaining part will behave in a different way chemically. It will in fact be a new chemical element. Thus if the nucleus is changed the ancient dream of the alchemists—the transmutation of the elements—is achieved.

The nucleus occupies only a very small fraction of the volume of the atom, for the volume occupied by the atom, or what may be thought of as its capacity for keeping its neighbours at a distance, is due to the action of its collection of electrons. The only way to attack the nucleus of an atom is by what may be roughly thought of as scoring a hit on it with the fast moving nucleus of some other atom. This is largely a matter of accident because the chances of hitting the very small nucleus are extremely low. Even if the nucleus is hit, the attacking particles must be moving very fast indeed if they are to disrupt the nucleus, for a very high energy is needed to produce any effect.

The first atomic bombardments were carried out with the aid of the particles (α-particles or the nuclei of helium atoms) which are ejected naturally in the breakdown of the nuclei of certain of the heavy elements which are radio-active. Radio-activity in an atom means, in fact, that its nucleus is unstable and is liable to break down of its own accord.

However, these naturally occurring particles are comparatively slow-moving, so that their power of doing damage to other atoms is limited. Also, they are not very numerous, and a large quantity of a radio-active substance such as radium would be needed to produce a powerful stream of ejected particles.

The means of producing faster particles is obvious. The nucleus of a helium atom has a positive electric charge and will therefore move if placed in an electric field. This is true of a charged particle of any kind. If we imagine an electron to move through a vacuum from one metal plate to another at a thousand volts higher (the negative electron is attracted towards the positively charged metal) it will have energy of motion which may be specified as 1000 electron-volts. The matter is on all fours with the fall of a material body down a precipice. A pound weight after falling a thousand feet has a thousand foot-pounds of energy. An electron, falling down an electric "hill" a thousand volts high has a thousand electron-volts of energy.

Now the energy needed to disrupt atomic nuclei must be measured in millions of electron-volts. Whatever particle we use as our projectile, whether it be the hydrogen nucleus (with a positive electric charge equal to the negative charge of the electron), or the deuteron (nucleus of "heavy hydrogen" with two electronic units of positive charge), we must provide an electric hill of the necessary height.

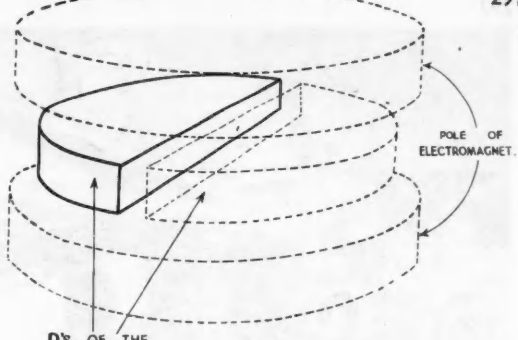

FIG. 4

To give a particle an energy of ten million electron-volts requires a hill ten million volts high. To maintain two electrodes at a difference of ten million volts is to incur all the engineering complications of super high voltages and although it is not impossible to achieve this, the technique is difficult and even dangerous. However, a device invented some years ago by Professor E. O. Lawrence of California, and since developed by a large team of workers, gives the atomic particles their energy, not all in one big dose, but in a series of comparatively small doses. This device is called the cyclotron, and already it shows signs of becoming industrially important. Its action may be compared to that of a swing. To set a swing in motion with a single impulse requires a considerable effort, but it can be easily set into motion by a series of small, *correctly timed* impulses. What the cyclotron does in fact is to apply a series of correctly timed impulses to the atomic projectiles.

Suppose we have an atomic particle bearing an electric charge, moving in a magnetic field. It will be found that the particle moves in a circle whose plane is perpendicular to the lines of magnetic force, and whose radius, for a particle of given speed moving in a given magnetic field, depends on its charge and mass. This is a well-known fact used, for example, in the mass spectrograph, which separates out atoms of the same charge but of different masses, or what are called isotopes. (See DISCOVERY May 1944; pp. 130–132, "The Mass Spectrograph".

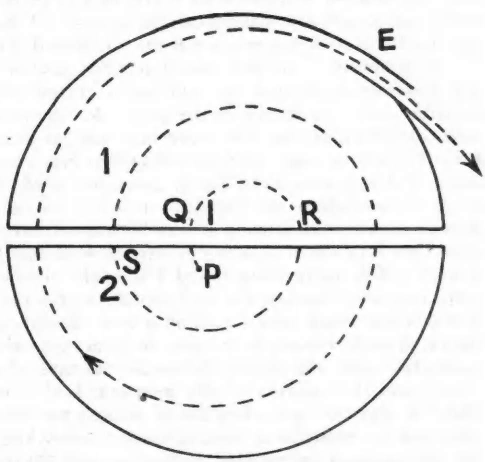

FIG. 5

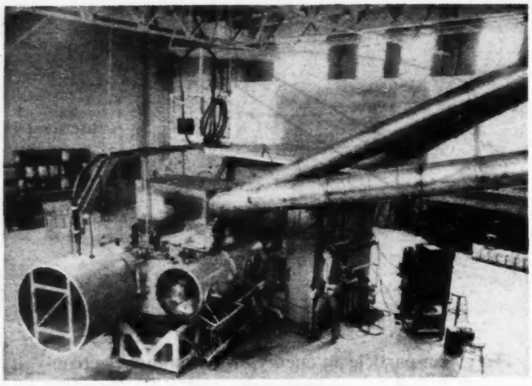

FIG. 6.—The cyclotron.

The cyclotron consists of an evacuated container in which the particles can move freely, placed between the poles of a very powerful magnet. Any charged particle moving in this container will therefore describe a circle. The second essential component of the cyclotron is a pair of metal electrodes shaped like two halves of a very flat metal pill-box divided by a vertical cut through the centre. The two conductors are very like two capital D's. Each is semi-circular in plan and hollow, forming a flat metal box with one curved edge and the straight edge removed. The two open edges are facing one another and the two dees are separated by a gap of a few inches. The atomic projectiles move inside the hollow of these two dees. Fig. 4 shows a rough diagram of the way in which the dees are mounted between the poles of the electromagnet so that the magnetic force runs vertically, perpendicular to the plane of the dees.

Fig. 5 represents a plan view of the apparatus. Suppose a negatively charged particle starts from P and moves in the direction of the arrow, and suppose that the dee marked 1 is positively charged to ten thousand volts as compared with the dee marked 2. Then as the particle crosses the gap it will receive a sudden kick corresponding to this potential difference and will gain an energy of ten thousand electron-volts. It will therefore move in a circle, finally arriving at R. If now matters can be so arranged that by the time the particle has reached R the potential difference has been reversed, so that dee 2 is now positive and dee 1 negative, the particle will get a further 10,000 electron-volts as it re-crosses the gap at R. It will now have 20,000 eV energy and move in a still larger circle RS. By the time it gets to S the voltage has been reversed again, and it gains a third energy contribution of 10,000 eV as it crosses from dee 2 to dee 1 at S. Fortunately the particle (unless it be moving at very high speed) takes the same time for each of its semi-circular paths, so that if the voltage difference between 1 and 2 is made to alternate with constant frequency, charged particles within the dees will describe spiral paths, gaining a new energy contribution at each crossing of the gap. In order to make the apparatus work, the voltage difference, the rate of alternation and the intensity of the magnetic field must be matched together, but when this is secured the particles may make as many as a hundred transits across the gap, thus acquiring, if the potential difference is 10,000 volts, a total energy of a million electron-volts. Finally, when the particles reach the edge of the metal dees they are drawn out by a deflecting electrode E at a potential of 50,000 volts or so, and form a beam of highly energetic particles whose effect on various substances can be investigated.

Naturally the working of such a complex apparatus as this, based though it is on a wonderfully simple idea, requires superlative engineering and experimental technique. Dr. M. Stanley Livingston has recently described some of the technical details of the new cyclotron built at the Massachusetts Institute of Technology. There the dees have a diameter of 38 inches and the magnet produces a field of 18,000 gauss (about 100,000 times as great as that of the earth). The charged particles are produced in a special type of arc at the centre of the dees and in endowing them with energies of 15 million eV a total power of 28 kilowatts is expended in maintaining an alternating potential difference of 140,000 volts between the dees. The atmospheric pressure on each face of the container in which the dees are housed is ten tons. The beam of particles issuing from the dees and striking the target is only ¼ of an inch high and ⅛ of an inch wide but an energy of ten kilowatts is concentrated on that small area. The action of such a powerful beam of particles on any object placed in its way is catastrophic, and in experiments the metal target being studied has to be water-cooled, and it must also be moved to and fro so as to spread out the area on which the particles impinge.

Stray radiations of all kinds are liable to be encountered, and the work is carried out in a specially constructed building with the controls in a room separated from the cyclotron by walls containing water tanks which absorb the harmful radiation and reduce it to intensities which are known to be innocuous. Every precaution has been taken to avoid the danger to the experimenters of burns by various types of radiation and to avoid a repetition of the serious physical injuries suffered by the early workers with X-rays. The photograph (Fig. 3) shows the cyclotron in use at Berkeley, California. The upper and lower coils of the electromagnet can be seen through the opening in the centre.

To the general public one of the most interesting applications of the cyclotron is in the production of artificial radio-activity. By suitable bombardment of certain elements, as for example, sodium, can be made artificially radio-active. In all other respects they are perfectly good sodium atoms, and can be taken into the body combined, for example, in the form of common salt. These specially "labelled" sodium atoms can then be detected during their absorption in various organs of the body by the radiations which they emit, and in this way valuable and detailed information can be gained about the way in which the various chemical elements are utilised in the bodily processes.

Omissions

ONE of the most interesting things about these notes from the compiler's point of view is the character of the subjects which are suitable for inclusion. It sometimes happens that a new and important piece of research is published which is likely to affect the general public quite closely,

but which is quite unsuitable for inclusion here because it is far too technical. It may consist for instance of very little more than a table of numbers or a collection of chemical formulæ, but if the numbers are data on the performance of a new type of weapon they may be the means of saving an army; or if the chemical formulæ describe, for example, the synthesis of quinine, they may be the means of safeguarding the health of whole nations.

It is a curious fact that some of the things which affect our lives most closely both in peace and war are in some ways the least intelligible. One of the reasons for this lies in the nature of scientific work. Suppose we take up one of these baldly written, apparently lifeless, scientific communications which may affect us so closely. It consists of a very condensed introduction, amounting in most cases to little more than a list of references to previous work. Following this will come an account of experiments or observations and particulars of the apparatus used in the work. Finally there will be a section of discussion and conclusions. Even to the semi-expert some of the topics included in the discussion may seem very oddly selected. The reader may be puzzled to know why the author has spent so much labour in refuting or confirming what seems to be a fantastic and irrelevant notion. The conclusions which so much excite the experts may leave the semi-expert with a sense of anti-climax best expressed in the Americanism "So what?"

This condensation and baldness of narrative are sometimes overdone. Even to the initiated reader a little more "background" might be a help, but limitations of space do demand, even in peace-time, that the paper shall be restricted to the bare essentials.

What is left out? First of all there is the human narrative of the research. A young man struggling with his first investigation may have expended six months of the hardest mental labour on an idea which proved fruitless. After half a year he has found that he must throw away the results of his work and start again. He finally carries the work through to a conclusion in face of disappointment and strain, and the work is published, looking as if it had flown straight from his pen with never a moment's interruption. Or again, there may be some demand that experimental results should be produced by a given date. The apparatus may have taken months to erect. Three days before the time limit when all is set to run straight ahead and take the observations (perhaps the least time-consuming part of the whole investigation) some vital component fails. Instances have been known where rush repairs have been carried out under conditions of considerable risk, or where the results have been attained with an apparatus nursed along by the crudest makeshift means. In some investigations of modern physics heavy engineering plant is used and a danger of failure means not only the possibility of a stoppage of work, but a real physical peril to the workers. Gremlins are usually associated with the R.A.F., but most scientists know that a particularly vicious species has inhabited laboratories from time immemorial. The perverseness of these creatures is best illustrated by the remark of an embittered young man: "If your experiments are going well, if your apparatus is working perfectly, if all your results agree with theory, sit down and ask yourself 'Where's the catch?'"

This is one side of scientific work which has rarely been described. One exception was in the film "Madame Curie" where the camera showed the evaporating dishes used in thousands upon thousands of re-crystallisations, but even there the audience could not be expected to feel in their own bones the prodigious determination and persistence and physical weariness which those re-crystallisations demanded.

The other great omission is of course the story leading up to the newly published investigation. In science it often happens that a particular point is reached where progress is held up. The cause of the delay may be something quite simple in appearance—perhaps nothing more than a single numerical datum—but half a dozen investigations may have failed to take the essential step, over, round or past the obstruction. As time wears on this particular datum becomes more and more important. Everyone in the field realises its importance, and knows the history of the various attempts which have been made. Finally, the essential advance is made. Two pages of print may announce the work and the method by which it was done. To the uninitiated it seems as if nothing worth talking about has been achieved and the enthusiasm of the experts is completely incomprehensible.

Nature does not yield her secrets easily, and each really big advance has probably required the work of many brains and pairs of hands. Ideas are put up for consideration only to be knocked down again. The apparent irrelevancy of some of the subjects discussed in many scientific papers arises in this way. The author has found something which is at variance with an apparently brilliant idea put forward by a previous worker and finds it necessary to discuss the point.

The writer recently had to expound a particular scientific advance to a learned society. On reading the latest investigation he was at first puzzled by some of the references and lines of argument adopted. In the end it proved necessary to include in the exposition a detailed account of no less than seven other investigations, the earliest of which was made over twenty-five years ago.

This particular research concerned a single highly technical subject which, even when fully described, would have been unsuitable for inclusion in DISCOVERY. What we try to give our readers in most cases is a well-rounded account of some investigation whose relevance will be immediately clear. It is rare in fact for any one item to be concerned with a single scientific paper. To produce an account a thousand words in length of some aspect of science may involve the drawing together of the work of dozens of scientists. In the most obvious cases of all, such as the radio-set or the motor-car, the theoretical and practical investigations of literally hundreds of people will have been involved.

Consider just one example, say, radio. This is now so huge a subject that bulky volumes are needed to contain the accumulated knowledge, so let us go back a few years to the time of Marconi's announcement that he had succeeded in sending a radio signal across the Atlantic. If DISCOVERY had existed then it would have included at least a note on this startling advance. If properly written it would have included first a reference to Faraday's discovery that electric currents propagated an influence across space. Clerk Maxwell as the founder of the

theory of electro-magnetic waves would have come in for special mention. Hertz's experimental work which first demonstrated this theoretical possibility would come next. It would be followed by references to the advances made by Edison and Oliver Lodge, and conclude with a reference to the development of the valve by Fleming and de Forest on the basis of the discovery of the electron by J. J. Thompson. If the writer had been very perspicacious he might have included a note on the curious fact that wireless waves propagated rectilinearly could travel round a curved earth, and might even have hazarded the opinion that some reflecting agency existed.

Our paragraph would in fact have been based on the fundamental discoveries of at least six scientists stretching in time over almost a century. This is an extreme example, but it does illustrate one aspect of scientific work and its popular description. Whatever may be said in defence of an individualist conception of scientific work, the facts are in sharp contradiction, showing just how essential scientific co-operation is, and how the character of the work itself imposes at least a rough and ready co-ordination of activity.

Between Ourselves

ONE of the thoughts that must have come into readers' minds upon first picking up this month's DISCOVERY was that its bulk is reduced. We hasten to say that this is more apparent than real and that it is only the substance of our paper dress that is this and not our body. There is no curtailment of the number of text pages or of the number of illustrations.

DISCOVERY, of course, experiences no more difficulties of production in these war-time months than many another magazine, but it is perhaps a little unfortunate in the amount of paper which is allotted to it under the paper quota. Before the war there was much less general interest by the reading public of this country in scientific matters than there is to-day. There were, indeed, fewer scientific workers and technologists. Consequently the demand—and hence the circulation—of the pre-war DISCOVERY was comparatively small when to-day's clamant demand for it is considered. In the eyes of the Ministry of Supply, the relation between interest in science and technology in the year 1938-9 and the year 1944-5 is static; whilst of course everyone else realises that it is much intensified. Yet a magazine's paper is rationed by weight in relation to its paper consumption in the year 1938-9. This fact, unhappily, leaves us in a poor position to face to-day's increased public interest in the broad fields of science which DISCOVERY covers.

We have endeavoured to meet this growing demand for DISCOVERY, not by curtailing its textual length, but by printing the magazine upon a lighter paper and by not allocating any of its precious text paper to advertisements. However, even this *modus operandi* has failed to ease a situation that grows increasingly more difficult to meet, for every month has brought disappointments to would-be readers who were unable to secure copies.

This month's DISCOVERY is printed upon even a lighter, albeit more expensive paper, but one which we believe may in some printing respects be better than the previous newsprint. It certainly will enable us to print more copies, and thus for a time avoid disappointment of some readers unable to get copies of their own. That this amelioration will be shortlived we know, but we hope that the military conditions will so have improved that a general increase in paper rations will be possible within the next few months. At the moment we believe it to be more important to disseminate scientific knowledge than to satisfy our typographical and technical aspirations.

We do therefore respectfully ask our readers' temporary indulgence in this matter, anticipating that you will agree with our decision not to meet the present situation by reducing the contents of the magazine (which, by the way, extends to approximately 30,000 words plus illustrations each month, which in its turn is much the same as before the war), but surmounting it by putting another tuck in the already somewhat stretched paper garment that covers our growing body. It may be an uncomfortable decision, but we hope that we shall not have to bear it long.

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Edible and Poisonous Fungi

B. BARNES, D.Sc., Ph.D., F.L.S.

FUNGI of various kinds have been eaten by man from time immemorial, though, except in times of distress, fungi seem to have been regarded as delicacies rather than as staple foods. In this country the mushroom is the only fungus which is universally accepted as fit to eat; the esteem in which it is held is shown by the prices it fetches in the shops. Until recently, the toadstool has been generally regarded here with suspicion and aversion, but it is now becoming popular and even fashionable, and an idea is abroad that the toadstool is not merely a desirable, but a specially valuable food. It seems well, therefore, to consider the position so far as it concerns the larger fungi.

The mushroom is but one of the many kinds of toadstools to be found in our fields and woods; it is not the only toadstool that can be eaten or that is worth eating; indeed, in its cultivated form, the mushroom is not as good as some of the wild toadstools, a strange reversal of the usual state of affairs. The cultivation of the mushroom on the commercial scale had led to the selection of a robust form, able to survive transport and to reach the shops in an attractive state, but this has meant some sacrifice of delicacy in texture and flavour.

It is probable that almost all kinds of wild toadstools could be eaten with no worse consequence than indigestion, but, just as it is not usual to make a casual gathering of grass and other herbage from a hedgerow and to serve that as green vegetables, so it is not desirable to make an indiscriminate gathering of toadstools and then to eat them. To qualify as an edible fungus, a toadstool should be acceptable in texture and flavour, it should be wholesome, it should be large enough to be worth the trouble of preparation, and it should be obtainable in adequate quantity; there are few kinds of toadstools which satisfy all these conditions.

Anyone who wishes to add wild fungi to his diet may do so with safety and pleasure, provided that a few simple rules are rigidly observed. There need be no accidents, and not even indigestion, if over-confidence and blind enthusiasm are kept in check. The main precautions are, to be sure that what is gathered for the table is in sound state, free from maggots, mouldiness and old age, and that the kinds collected are known to be wholesome. The best way of learning how to distinguish the wholesome kinds is to get personal instruction from someone who knows them, and who will back his knowledge by eating the kinds he recommends. Failing such instruction, recourse may be had to suitable books; provided scrupulous care is taken, it is not difficult to learn how to recognise a few of the principal larger fungi.

No trust can be placed in the various tests which have been proposed by this or that writer to distinguish good from poisonous fungi. The most poisonous toadstool in this country is the death cap (*Amanita phalloides*), a really dangerous thing (Fig. 1). It passes with credit a number of the tests which have been stated to certify innocence; it does not blacken a bright sixpence or a silver spoon, its cap peels easily, and it is eaten by rabbits and by slugs; in short, the tests indicate that this very poisonous fungus is harmless. Clearly the tests are useless. There is no safety in a method which was at one time widely advocated in France, where fungi are much more widely eaten than they are here. It was said that an indiscriminate collection of toadstools could be safely used as food if they were all first boiled for a time in brine, washed thoroughly in cold water and the prepared for the table. It does not appear that anyone has treated the death cap in this way and then eaten with impunity; it is known that persons who have eaten the death cap after brining have regretted their temerity. Fabre, the famous entomologist, strongly recommended the brine treatment in the tenth series of his *Souvenirs entomologiques*, but from the account he gives there he does not seem to have tested personally anything more noxious than the honey agaric (*Armillaria mellea*), which, though rank and nasty, is not really poisonous—and is not worth eating. In his *Lectures sur la botanique*, a much less well-known work than the *Souvenirs entomologiques*, Fabre begins his advice to would-be

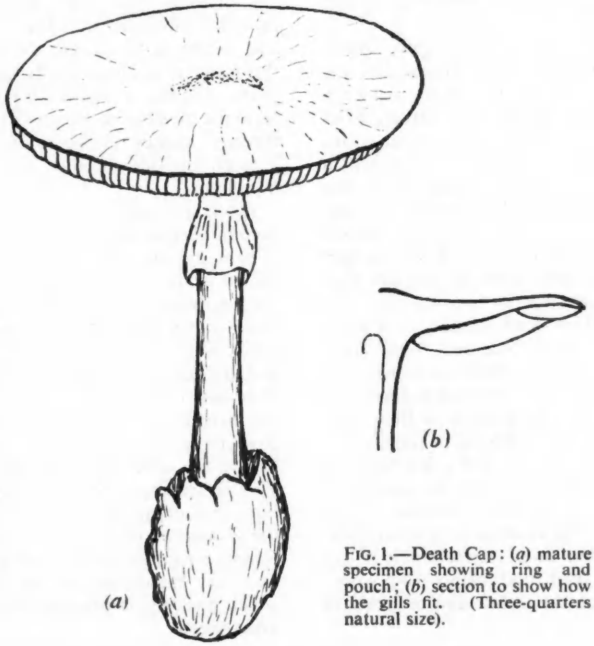

FIG. 1.—Death Cap: (*a*) mature specimen showing ring and pouch; (*b*) section to show how the gills fit. (Three-quarters natural size).

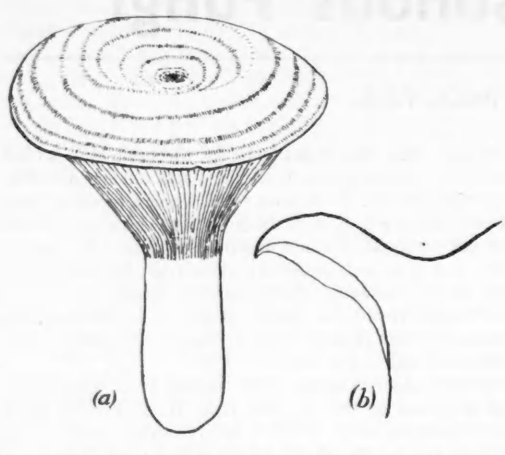

FIG. 2.—Saffron Milk Cap: (*a*) mature specimen; (*b*) section to show how the gills fit. (Three-quarter natural size).

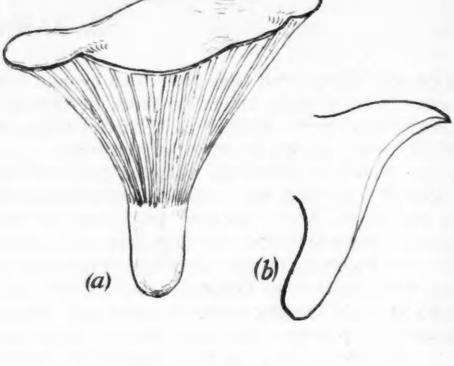

FIG. 3.—Chanterelle: (*a*) mature specimen; (*b*) section showing the shallow gills. (Natural size).

fungus-eaters by the very excellent statement, "Unless you have absolutely reliable botanical knowledge, eat only those kinds which are generally recognised as wholesome in the district where you live"; he follows this by advising brining as an additional precaution.

It is quite unnecessary for anyone who wishes to experiment with edible fungi to be able to recognise and name all the toadstools he may find; it is necessary only to learn to recognise a few of the good kinds, and one or two of the poisonous kinds. But, even with so limited an objective, it is as well to know something of the nature of the fungi.

Toadstools, including mushrooms and some other fungal structures to be mentioned in due course, are the fruit bodies of certain fungi. Fungi are usually regarded as plants, but they have none of the obvious characteristics of our ordinary garden plants. They have neither roots, leaves or flowers and they lack the green pigments which enable ordinary green plants to use energy from the sun and to make up their foods—carbohydrates, fats and proteins—from simple substances such as water, carbon dioxide, and mineral salts from the soil. Fungi cannot make food from simple beginnings, and, like animals, they have to get their food, and the energy it contains, either directly from living plants, from dead substances of plant origin, or from other sources which trace back to the green plants. The mushrooms and many other toadstools live on dead organic matter in the soil; other fungi depend in part on this, at the same time taking some of their food from the roots of living trees, any one kind of fungus as a rule being associated with one or with but a few kinds of trees, though several kinds of fungi may be associated with any one kind of tree. It is partly because of this association that, in general, the toadstools characteristic of pine woods are different from those characteristic of oak woods. Still other fungi get their food mainly from wood, and form their fruit bodies on the trunks and branches of trees, stumps, and the like.

How the Fruit Bodies Arise

Toadstools and other fungal fruit bodies are complicated structures on or in which the spores (the minute reproductive bodies so characteristic of the fungi) are formed, and from which the spores are set free. They are not unhealthy growths, for they are just as much a normal product of the fungus as apples and pears are normal products of the trees which bear them. Like apples and pears, the fruit bodies of fungi seldom last long, but they do not form in a night. Below ground, or in the wood or other substance that the fungus is using, there grows and works a spreading system of branching threads; this is the mycelium of the fungus, and it may last for many years. Lumps of rich earth permeated with such threads form the mushroom spawn of the seedsman, and the white thready masses so common among rotting leaves in autumn provide another familiar example of a fungal mycelium.

When a mycelium has grown for some time and has accumulated a store of food in its threads, there form on it, here and there, little pellets of densely crowded threads, buried in the ground or other material. These pellets are the beginnings of fruit bodies. This formation of rudiments takes place in many fungi when a period of wet, rather warm weather follows a period of hot, dry weather, and this helps to explain how toadstools tend to be specially abundant in late summer and early autumn. In general, the threads on the outside of the pellet soon form a firm covering, protecting all that is inside, and within that envelope the other parts of the fruit body are organised. This is accompanied by steady enlargement, and by the time that organisation is nearly complete the surface of the ground or of the bark is reached and broken. There follows a rupture of the envelope, at any rate in toadstools, and very rapid onset of maturity; it is this last stage which gives the impression that toadstools form with very great speed.

Points in Identification

Almost all toadstools are built on a uniform plan, with variations in detail. In its simplest terms, a toadstool consists of an upright stalk supporting a cap set horizontally and symmetrically above it. The whole structure is like an obese umbrella. When the cap is fully spread out, it may be flat on top, or somewhat conical with a central boss, or funnel-shaped with a central depression, or more or less completely dome-shaped; its upper surface may be smooth, or covered with scales or warts, sometimes marked with radiating lines, and very diversely coloured. Hanging from the lower surface of the cap there is commonly a large number of radially-directed plates, the gills, some long, some short. All go to—or nearly to—the margin of the cap, but the shorter ones do not reach the stalk. In some toadstools, the longer gills just do not reach the stalk; in others they do so; while in others they join it and have a little indentation below close to the junction; and in yet others the longer gills grow for some distance down the stalk. Usually there is a clear line of separation between the centre of the cap and the top of the stalk. Not all toadstools have gills. Instead, some have below the cap a crowded system of vertical tubes, opening by rounded or irregular pores below. In addition to the stalk and cap, some toadstools have a pouch around the base of the stalk. To see this it may be necessary to dig up the whole fruit body, as the pouch may be underground; the pouch is the remains of the basal part of the envelope which was torn asunder as the stalk lengthened. In addition to the pouch, there may be a ring around the stalk a little below the cap; ring and pouch may both be present, or only one may be there. A few toadstools exude a milky juice when wounded, and some change colour when cut or bruised surfaces are exposed to the air. All these characters, together with the colour of the spores, are used to help us to recognise the various kinds.

The spores are borne on the gills or on the sides of the tubes. Individual spores are too small to be seen without the aid of a microscope, but they may be obtained in mass and their colour determined by cutting off the cap and placing it in its natural posture on a sheet of paper. The spores fall, and stick together and to the paper, and in mass the colour is easily seen. It is important, when dealing with a toadstool of which the name is not known, to find out the colour of the spores, for this character is the basis of the classification used in the books. The spores are not always of the same colour as the gills; mention will be made later of two toadstools which have yellow gills, but white spores. With experience, it soon becomes possible to recognise some toadstools at sight, by their general appearance, just as we recognise our human acquaintances; but in starting, all characters must be carefully and separately observed.

A few kinds of fungi form edible fruit bodies which are not toadstools. Some have a short stalk, or no stalk at all, and the fruit body grows out from wood or bark as a sort of clumsy semi-circular bracket; these are the bracket fungi. Others, the puffballs, are globular to top-shaped objects without a distinct stalk, and without gills or pores. When young puffballs are cut into, they are white all through, and it is only in this state that they are fit to eat. Sometimes, in pinewoods, there may be found large creamy-white fruit bodies looking something like a loose untidy curd of a cauliflower; this is *Sparassis*, esteemed by some, but it is often gritty and uncomfortable to eat.

The most Dangerous Species

For present purposes, if the toadstool has a symmetrical cap, often quite flat on top, borne on a long graceful stalk with a ring and a basal pouch, and with white spores borne on whitish gills that just reach the stalk but do not join up with it, the fungus is an *Amanita:* all species of *Amanita* are best avoided by the novice. The death cap (*Amanita phalloides*) and the fly agaric (*Amanita muscaria*) as well as several other common toadstools, belong here. The fly agaric, with its scarlet top dotted with whitish warts, often abounds under birch trees, and may be found under pines. It is the toadstool most often pictured by artists in fanciful illustrations intended for children. It owes its name to the circumstance that the milk in which the cap had been crushed was formerly used to kill flies. The fly agaric is poisonous, but probably not deadly to a healthy person. The death cap (*Amanita phalloides*) is found in damp shady places, and is sometimes very common. It is attractive and of innocent appearance. The cap is usually whitish to pale yellow with a tinge of green, and often marked by thin clear dark lines. This toadstool must be left severely alone. It contains at least two poisonous substances, one attacking the alimentary canal, the other, more leisurely, the central nervous system; if poisoning by this toadstool is suspected, medical aid must be obtained at once.

In pine woods, the saffron milk cap (*Lactarius deliciosus*) (Fig. 2) is sometimes very common; it has long been a favourite, though its virtues have perhaps been overpraised. When cut, this toadstool exudes drops of yellow milky juice; bruised surfaces turn yellow and finally green. There is neither pouch nor ring. The white spores are borne on yellow gills, which run across the cap and some distance down the stalk, the effect of this being increased by the circumstance that when the toadstool is mature, the cap is often funnel-shaped with a central depression. The upper surface of the cap is yellow, marked with darker concentric bands.

Another yellow toadstool with white spores is the chanterelle (*Cantharellus cibarius*) (Fig. 3). There is no pouch or ring, and the whole toadstool is usually egg-yellow, though it may be whitish. The gills are low blunt ridges, not plates, and they often join up as they run on to the stalk; there is no sharp line of separation between cap and stalk; the stalk is solid, a feature which serves to distinguish the chanterelle from a somewhat similar toadstool of dubious reputation, and the margin of the cap is wavy. The chanterelle grows in woods, often under oaks, and is sometimes very abundant. It has been a favourite esculent for a long time; it is good for flavouring soups, but its firm texture makes careful cooking necessary if it is to be used for other purposes.

The parasol mushroom (*Lepiota procera*) (Fig. 4) is perhaps the best of the edible toadstools. It may be nearly a foot high and some eight inches across the cap. The stalk is swollen at the base, but there is no pouch. A loose moveable ring surrounds the stalk a little below the cap. This ring is white above and brown below. The cap,

FIG. 4.—Parasol mushroom: (*a*) mature specimen; (*b*) section showing how the gills fit; (*c*) young specimen, the cap of which is beginning to spread out. (Half natural size).

well provided with brownish scales on its upper surface (similar but smaller scales occur on the stalk) is conical with a central boss. The whitish gills do not quite reach the stalk, and bear white spores. The parasol mushroom favours open places, such as heaths, pastures and roadsides; it is well worth gathering and cooking.

The mushroom (*Psalliota campestris*) is unmistakeable. The wild form is most common on ground where cattle provide plenty of droppings, but it is fitful in its appearances. The top of the cap is usually silky rather than scaly, as in the cultivated form. Young specimens are button mushrooms. In these, the gills, which do not reach quite to the stalk, are white, or sometimes slightly pink, but as the cap opens out and the dark purplish-black spores ripen, the gills darken and blacken. A distinct white ring lies just below the cap, but there is no pouch. The preference of the mushroom for heavily manured ground, and its frequent occurrence on old manure heaps which have been lightly covered with earth (matters of common knowledge), contradicts another alleged test for poisonous fungi, namely that toadstools on manure heaps are not good to eat.

Fairy rings in lawns and in meadows are familiar to most people. They are caused by a variety of fungi, of which the fairy ring champignon (*Marasmius oreades*) (Fig. 5) is the commonest. This is a rather small, somewhat leathery toadstool, which, unlike most of its kind, shrivels in dry weather and revives when wetted. Cap and stem alone are present, and both are buff-coloured with a tint of red. The gills are few, widely spaced, and rather broad, and bear white spores. The stalk feels rather like a piece of rubber. The fairy ring champignon is usually dried and kept as a flavouring for use in the winter; freshly gathered specimens may be cooked in fat, and dried caps can be soaked in water and treated in the same way.

Two toadstools without ring and pouch, and with pink spores borne on gills which reach to the stalk and usually show a little indentation below, belong to *Tricholoma*. The gills come away from the cap more easily than is usual in toadstools. Blewits (*T. personatum*) is a grassland species, white wood blewits (*Tricholoma nudum*) is found in woods. Both, especially when young, are distinctly blue or lilac, but the caps become browner with age. Both are collected and sold in the Midlands and North. Wood blewits can be grown on compost heaps, and it might be worth while developing this method of cultivation.

Deposits of miscellaneous rubbish by roadsides and in gardens are sometimes abundantly occupied by the shaggy ink cap, (*Coprinus comatus*) (Fig. 6) which differs in several respects from the toadstools so far mentioned. The young fruit body looks rather like a small egg with a few brown scales on its surface; later, whitish scales are developed freely. The cap never opens out completely. As it comes away from the stalk a ring is left, and soon afterwards, as the black spores ripen, the edge of the cap is changed into an inky fluid, and this change passes quickly across the cap, after about two days leaving the remains of the centre of the cap perched on the ink-blotted stalk. If this toadstool is gathered young, before the change into the inky fluid begins, it makes a delicious dish.

Among the common toadstools in wooded country, there are several kinds in which the cap bears below a mass of crowded tubes instead of gills. Of these, the cep (*Boletus edulis*) (Fig. 7) beloved by the French as the *cèpe*, is a famous esculent. When young, the disproportionately large stalk is crowned by a small cap; as this spreads out, the stalk may remain rather short and swollen or may lengthen into a cylinder; whatever its form, it bears a whitish network on the part just below the cap. The cap is robust, and is commonly likened in appearance to a penny bun, smooth on top and brownish-yellow to rich brown, with a white margin. The thick, firm flesh of the cap is white, with a thin pinkish layer just below the brown outer surface. Other species of *Boletus* are common; two with brown tops and cylindrical stalks sprinkled with small black scales, are edible; others which show violent changes of colour when they are cut or broken are best left alone.

Of the bracket fungi, many kinds of which are common on the trunks and branches of trees, one only need be considered as edible; most of them are too tough to be eaten. The edible kind is the beef steak fungus (*Fistulina hepatica*): it occurs on oaks, usually not far from the ground, and commonly on trees which are stag-headed, that is, with several irregular dead branches standing up aloft like deformed antlers. The fruit body of the beef steak fungus develops very quickly, and may become very large, weighing several pounds. The upper surface is blood red, slimy when wet, and moves under the hand.

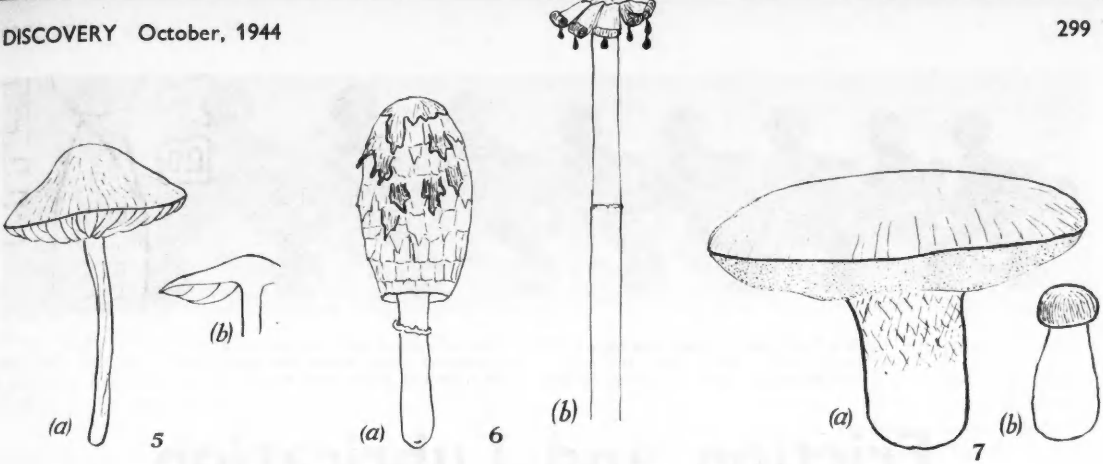

FIG. 5.—Fairy ring champignon: (*a*) mature specimen; (*b*) section to show how the gills fit. FIG. 6.—Shaggy Ink Cap: (*a*) young, in condition fit to eat; (*b*) the characteristic old-stage when most of the cap has dissolved into inky drops. FIG. 7.—Cep: (*a*) mature specimen; (*b*) young specimen. (All natural sizes).

When cut across, a reddish juice exudes freely, and the cut surface is streaked in red and pink, something like the cut surface of beetroot. The lower surface of the cap bears a dense layer of small tubes with very small pores. Opinions vary about the value of this fungus. Its texture is usually good, because of the rapid development, but the flavour is coarse, so that the abundant meal promised by the heavy fruit body may disappoint in quality. Young specimens are usually acrid.

Puffballs are so well-known that they hardly need description; they are fit to eat only when they are young, and show a uniform white surface when cut into. When cut, puff balls give out a pleasant odour, and this serves to distinguish them from young specimens of another fungus, often abundant on shady banks on a light soil. This fungus (*Scleroderma*) looks rather like a deformed golf ball, and when cut produces an unpleasant rank smell; it is to be avoided.

It remains to discuss briefly the food value of the wild fungi. In the present state of our knowledge it is not possible to make any definite statement on the point. Chemical analyses show that in general composition the fungi do not differ in any important way from ordinary green vegetables, and they seem to be less readily digestible than are green vegetables. There is no reason to think that they contain any special substances of particular nutritive value, but so far no one seems to have carried out any critical feeding experiments. Probably, the age-old opinion that certain fungi are delicacies to be eaten because they are delicacies is the sound view: maybe their value is diet is more psychological than physiological.

Post-War Aeronautical Research

A BOLD policy for aeronautical research was urged by Sir Henry Tizard when he addressed a meeting of the Parliamentary and Scientific Committee this month (October). As Sir Henry has been connected with research in aeronautics for the past quarter of a century—for ten years he was chairman of the Government's Aeronautical Research Committee—his pronouncements carry particular weight and are not likely to go unheeded in official circles. He advocated a block grant from the Government of at least £1,000,000 for research into the problems of civil aviation, and he urged that a new Aeronautical Research Council should be established under the Lord President of the Council (who is responsible for co-ordinating all Government activities in the realms of scientific and industrial research). He suggested that the chairman of the Research Council, which would have executive control, should be an experienced industrial engineer. The creation of such a body would be accompanied by the divorce of civil aviation research from work on military machines.

He emphasised the point that large numbers of civil machines are not likely to be required in the post-war years. The revenue of internal air lines would amount probably to only $2\frac{1}{2}\%$ of the revenue of our railways. That would be about £8,000,000, and would involve a force of some 80 aircraft, which would be maintained by from sixteen to twenty additional planes each year. Better and better plane construction would be the secret of commercial success. This success would largely depend upon our attracting young men into aeronautical research. He said he was not alarmed that we were reaching the end of the war with virtually no civil aircraft. If we got down to research in the right way and if sufficient money were made available to support that research we could, in five years, do as well as any other nation.

Sir Henry forecast the development of passenger planes with pressure cabins that would travel at speeds above the speed of sound, and expressed the view that there could never be a regular or economic service across the Atlantic below the 40,000 feet level because at lower ranges, storms would be liable to interfere.

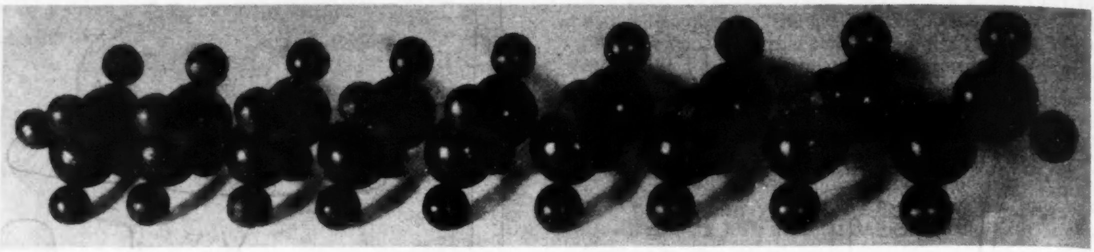

FIG. 2.—Model showing distribution of the atoms of carbon and hydrogen in a straight-chain hydrocarbon. The large spheres represent carbon atoms, the small ones hydrogen atoms. (*Reproduced from "The Science of Petroleum", Vol. IV*).

Friction and Lubrication

J. E. SOUTHCOMBE, M.Sc., F.Inst.Pet.

THERE is a story told of Leonardo di Vinci that upon seeing some fishermen struggling to drag a long length of rope over the sands he suggested that if they would coil it into a heap it would be much easier to drag as there would be a smaller area of rope in contact with the sand. When this was done, he was astonished to find that there was no reduction in the force required to drag the rope.

This appears to be the first recorded observation that the friction between dry solids is independent of the area of contact. In 1699 Amontons and later Coulomb (1785) showed that Dry Friction is proportional to the pressure or load pressing two solid surfaces together and independent of the contact area within the limits of their tests.

A very simple way in which friction between two solids can be measured is illustrated in Fig. 1:

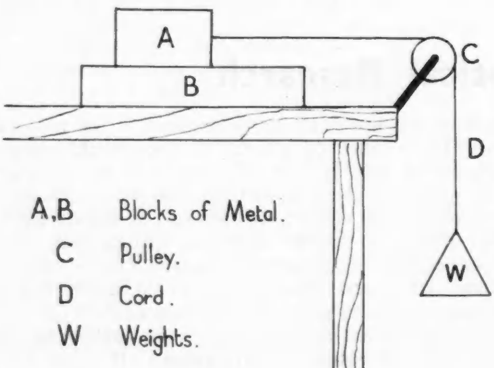

FIG. 1.—A simple device to measure friction.

If a heavy block of metal *A* of weight *W* rests on another slab *B* and a weight *w* is applied to a cord attached to *A* over a pulley *C*, it is found that the block *A* will not move over the surface *B* until a certain definite weight is applied to the cord. The minimum weight which will just cause the block *A* to move is a measure of the static friction between the two metals, and if we divide this weight *w* by the weight of the block *W* we get the co-efficient of static friction; e.g., if the weight of the block is 5 lb., and 1 lb. must be applied to the cord to cause movement, then the co-efficient of static friction is $\frac{1}{5} = 1{\cdot}2$.

The following table gives a typical result of varying the weight of the block for two surfaces of clean dry solids:

Weight of Block *W* lb.	Weight required to cause slip *w* (lb).	Co-efficient of static friction
		$\frac{w}{W}$
5	1	0·2
10	2	0·2
20	4	0·2

It is seen that the total friction *w* goes up in direct proportion to the load or weight *W*, while the co-efficient remains constant for any particular pair of dry solids. This is known as Amontons' Law.

The co-efficient varies for different solids, being quite different for, say, glass on glass as compared with steel on steel. The early workers were not aware of the difficulty of preparing chemically clean surfaces, and their results must have been obtained on solids more or less grossly contaminated by films of foreign matter; but in 1910 Lord Rayleigh, experimenting with chemically clean glass surfaces, noticed that the friction of glass on glass was much reduced by simply "greasing" a clean plate by rubbing with fingers which had simply passed over the hair. He estimated the thickness of this "lubricating" film as about 4 millionths of an inch and he considered the thickness of a layer required to cause "slipperiness" was probably much less than this. It is found that Amontons' Law applies not only to the friction of clean dry-solids but also to surfaces contaminated by invisible films of lubricants, but

the quantitative value of the co-efficient is generally much smaller in the latter case. The condition in which an impalpable layer of liquid influences the friction of the solid has been called Boundary Lubrication, since it is a function of the "boundary" where fluid meets solid and is quite distinct from that state where the surfaces are separated by relatively thick films of liquids known as Fluid Film Lubrication, as we shall see later.

During the last quarter of a century a great deal of study has been devoted to boundary lubrication, not only for its importance in engineering but also because of its interest as a problem in the wider realm of the physical chemistry of solid/liquid interfaces. The outstanding workers in this subject have been Irving Langmuir, Sir W. B. Hardy, F. Bowden, and their collaborators.

What is Friction?

First let us inquire what is the cause of friction; it used to be thought that it resulted from the interlocking of the high spots or "asperities" of the comparatively rough surfaces of the solids, since it is clear that however perfectly machined or polished there will always be irregularities on the surface, but it is now known that improvement of the surface finish does not necessarily result in reduced solid friction, and indeed since such excellent surfaces as optically polished glass can show such high friction that the surfaces cannot be rubbed over one another without tearing we are led to conclude that the "asperities" must be the molecules themselves and ultimately that dry solid friction results from some attraction between molecules in the surfaces acting across the interface.

All matter is made up of immense numbers of ultimate particles called molecules, each one of which exerts a force on its neighbours. In the case of solids or liquids this is particularly manifested as an attraction for each other exerted radially all around it. Every molecule inside a solid is surrounded by others, so that its attractive force is balanced on all directions; but those which lie in the surface layer while pulled inwards and sideways by neighbouring molecules have no corresponding force exerted on them outside the surface. Consequently, these surface molecules have an unbalanced attractive force which extends outside the surface to a distance of about one hundred millionth of an inch. Seizure will occur if two such solids are brought within this range of each other unless the field of force has been wholly or partially saturated by a lubricant.

Incidentally, the National Physical Laboratory some years ago took two block gauges, highly polished pieces of steel, moistened them with kerosene, then repeatedly pressed them together and pulled them apart again.

After repeating this process some thousands of times the gauges were again accurately measured, when it was found they had decreased in length by an amount which was approximately equivalent to the detachment of an atom of iron from the surface every time they were pulled apart. As a result of this force, not only have solids some attraction for each other but they can also cause molecules of liquids to adhere strongly to their surface layers forming a kind of composite surface in which solid and liquid forces become mutually satisfied. Two solids covered by such layers slide over each other comparatively easily and the presence of films of certain substances which are so thin that they represent a layer only a few molecules, or even a single molecule, thick can reduce the friction to one tenth that of the chemically clean solids. It is, however, not generally realised how difficult it is to prepare clean surfaces; a solid has to be treated with solvents and chemicals or even rubbed with abrasives while handling it with tongs and storing immediately in purified air to obtain a clean surface.

Molecules that Change their Shapes

Not all liquids are capable of being anchored to a solid surface and reducing friction and only those are efficient, whose molecules possess long chains of carbon atoms coupled with a special structure known as "Polarity". If we throw a handful of ping-pong balls across a billiard table they will run in all directions and no one can tell what particular spot on the surface of a ball will be pointing downwards when they come to rest; each ball is symmetrical. Suppose however that during the manufacture of the balls a small piece of lead had been cemented somewhere inside each ball—giving them what a bowls player would call a bias—these balls would all come to rest with the weighted spot more or less directed downwards to the table, because they are unsymmetrical or "polarized". This gives a rough idea of what we mean by "Polarity", but the matter is further complicated by the amazing fact that the molecules have "shapes". Some are like spirals with similar tails at each end; others have a tail at one end and a head at the other—these are "polar" molecules; while still others are more or less flat discs.

Three Kinds of Oil

We have learnt a lot about the shapes of these molecules by observing what happens when a spot of insoluble oil is dropped on to the surface of clean water. It will suffice to describe three kinds of oily material. The so-called mineral oils are mixtures of what the chemists call hydrocarbons because their molecules are built up from the two elements carbon and hydrogen. Generally speaking, their end groups or tails are similar in structure and they may be described as symmetrical or non-polar molecules. These particular oils do not spread on water, but remain as lens-like drops surrounded by pure clean water; they have little power of reducing the friction of solids when deposited on them in layers of only a few molecules in thickness (Fig. 2).

Then come the natural animal and vegetable oils, which are built up from glycerine chemically combined with three long chain fatty acids; these are called triglycerides. These oils spread on a water surface because they contain oxygen in their molecules and have some affinity for water; they also can reduce friction between solids to which they become anchored. Finally there are the fatty acids obtained by splitting off the glycerine from fats in which they occur; these are oils or low melting waxy-looking substances and they possess the properties of spreading on water and of reducing the friction of solids to an exceptional degree.

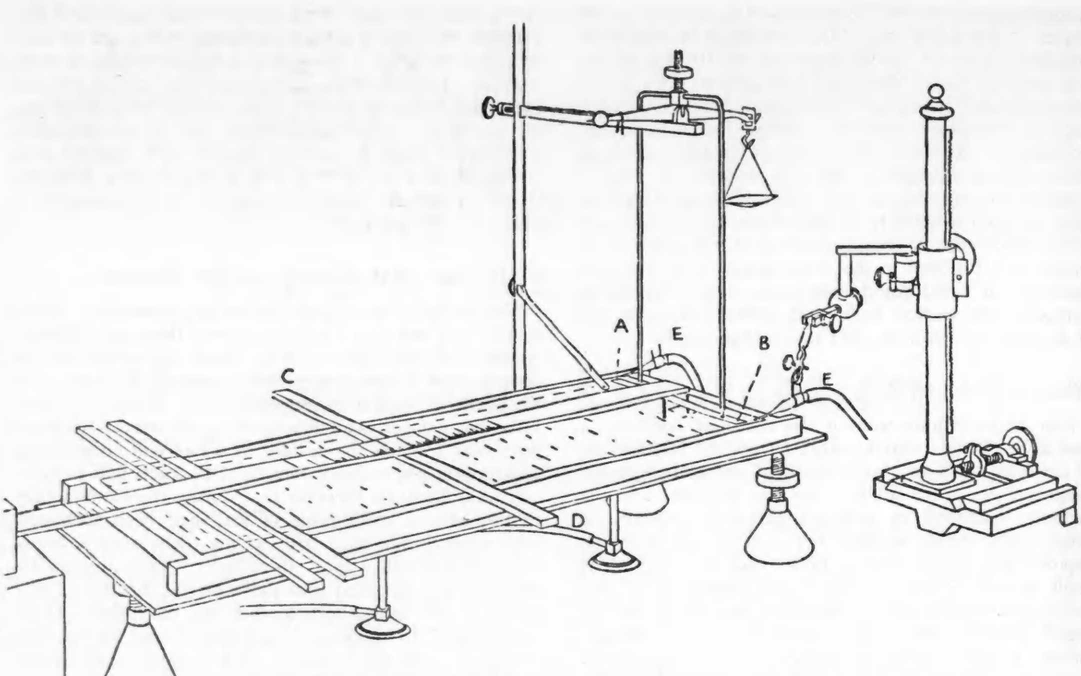

FIG. 3.—N. K. Adam's modification of Langmuir's trough for studying surface films on water. (*Reproduced from "Chemistry and Physics of Surfaces" by N. K. Adam*).

AB, floating barrier suspended from balance.
CD, movable barrier.
E, E, air jets to prevent leakage of film past the sides of the barrier.

Molecules that Stand on their Heads

The technique for studying films on water originally introduced by Rayleigh and Pockels has been beautifully developed by Langmuir and Adam. If a minute quantity of, say, palmitic acid dissolved in an inert volatile solvent is dropped on to a large surface of clean water it is found to spread rapidly as an invisible insoluble film. This film can be swept back to occupy a smaller area on the water by simply dipping a sheet of cardboard the width of the vessel into the water and moving it back, whilst at the other end of the bath or trough can be dipped a similar piece of board attached to a delicate balance whereby any pressure on this cardboard barrier can be detected. It is found that as we slowly sweep back the film from a large area of water to a smaller area nothing happens until the palmitic acid layer is just enclosed in a certain definite area, after which the slightest attempt to sweep the surface further results in a pressure being registered on the balanced barrier due to the film resisting any further reduction within its area. Without going into further detail here, it can be stated that at this point the water is just covered by a layer of single molecules of the fatty acid touching each other as they float on the water as would a handful of corks. This is called a mono-molecular film of fatty acid, and of course from a single drop there are many millions of them floating together. Now the total number of molecules can be calculated from a knowledge of the weight of the palmitic acid used, and the area of this single layer on the water can be measured so that we get the area occupied by a single molecule.

The volume of this molecule can also be calculated, and by dividing this by the measured area we get the length or depth of the molecular layer. All these measurements are so exceedingly small that the physicist has to use a special unit of measure known as the Ångström to describe them—there are 250 million Ångström units in one inch. In the case mentioned, the volume of a molecule of palmitic acid is known to be 495 cu. Å units whilst its area on the water is found to be 20·5 sq. Å; hence its length perpendicular to the water must be

$$\frac{495}{20{\cdot}5} = 20{\cdot}2\ \text{Å}$$

The breadth or width is $\sqrt{20{\cdot}5} = 4{\cdot}55$Å which is about $\frac{1}{5}$ of its length. It follows that the molecule must be elongated, its length being about five times its breadth; and it must be sticking up almost perpendicular to the water surface. It is the oxygen atoms in the palmitic acid which mingle with the water molecules, and since these are concentrated at one end of the long carbon chain the molecule must be standing on its head. This head is called the "Polar" group of atoms and gives the molecule a kind of bias.

The various fatty acids contain different numbers of

carbon atoms, i.e. the chains of atoms have different lengths; but all these occupy the "same" area, and their length is proportional to the number of carbon atoms in their chains, thus providing further proof of this orientation of the molecule on the surface. Now if a chemically clean sheet of glass, e.g. a microscope slide, is dipped edgewise into water on which a mono-molecular film of fatty acid floats and is then carefully withdrawn, allowed to drain, and the water evaporated, a single layer of molecules can be transferred to the glass. Langmuir deposited such a film on glass and found that while the co-efficient of friction for the clean glass was about 0·9 the mono-molecular film reduced it to 0·13.

In its simplest form we can picture two surfaces, each of which is coated with a single layer of lubricant molecules with the polar heads fixed to the solids and the tails sticking up so that the plane of slip is between the two tails (Fig. 4).

However, the matter is not quite so simple. Referring again to the sheet of glass on which a mono layer has been deposited, it is found that if it is dipped again a second layer can be formed on top of the first, but now the orientation is reversed (Fig. 5), the polar head being directed away from the glass. On this yet a third layer can be formed, with the heads together, and so on. In this way films many scores of molecules thick can be formed. This orientation of the molecules in boundary lubricating films has been confirmed by X-ray photography and by the electron diffraction camera.

While several workers were engaged in studying surface films by methods outlined above, Sir William Hardy and others were conducting experiments on friction in the boundary state by measuring the pull required to start motion of a curved slider resting on a plane, the lubricating film being either deposited from a volatile solvent by evaporation or placed on the surface and then "wiped" off by a cloth. It should be noted that these boundary films adhere so firmly that simple wiping will not dislodge them. In order to obtain information of a fundamental character Hardy commenced by testing the lubricating properties of pure chemical compounds. His first experiments were made with a range of hydrocarbons, alcohols and fatty acids of varying molecular weight, i.e. molecules of different length. The graph (Fig. 6) shows that the friction falls linearly as the molecular weight of the lubricant rises in each of these families of organic compounds, until in the case of the fatty acids the coefficient approaches vanishing point for members of 16 carbon atoms and over. The tail is of course getting longer and longer as the molecular weight increases.

It has also been found that the lubricating efficiency of a commercial mineral oil can be improved by adding to it small amounts of the higher fatty acids; this has been patented and the oils made on this principle have been in practical use for several years. Fig. 7 shows the remarkable effect on the coefficient of friction of cast iron on bronze when lubricated with a boundary film of mineral oil to which small quantities of oleic acid have been added; it is to be noted that so small a quantity as one part of the latter in a thousand parts of oil reduces the friction markedly. The property whereby one lubricant is more efficient in reducing friction than another of identical viscosity has been called "oiliness".

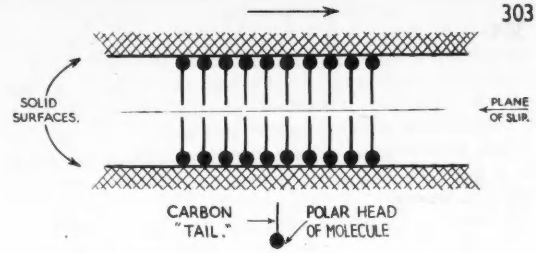

FIG. 4.—Diagram illustrating orientation of fatty acid molecules on solids. A mono-molecular film on each surface is shown.

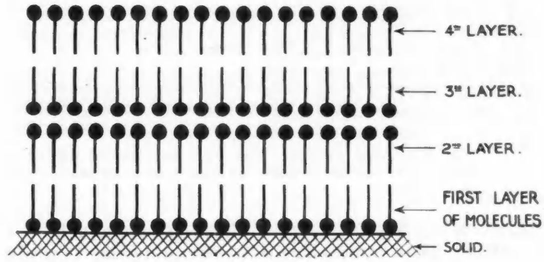

FIG. 5.—Diagram illustrating orientation of multi-molecular layers on a single solid surface.

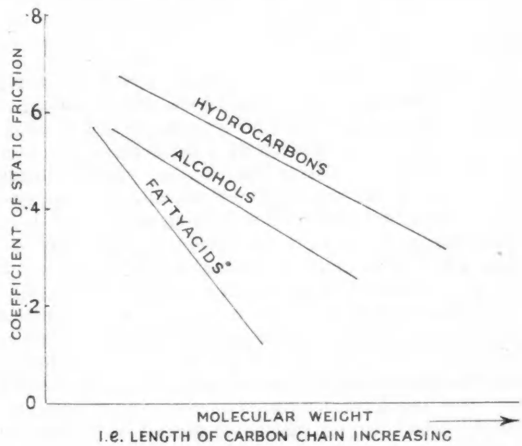

FIG. 6.—Graph showing linear fall of friction.

As is to be expected, the composition of the solid faces influences the value of the friction with any given boundary lubricant, and when two different solids were used Hardy found the friction to be the arithmetic mean between that of the two materials when used in pairs, i.e. each solid face makes its own contribution to the friction. When the lubricant is a pure chemical individual such as cetyl alcohol or palmitic acid, the friction is not affected by temperature and the coefficient remains constant; but in the case of mixtures one component of which can be selectively adsorbed by the solid the friction falls with rising temperature, and there is also a period of falling friction with time when polar compounds are present; but this does not occur with pure non-polar hydrocarbons.

The foregoing is a brief account of the information

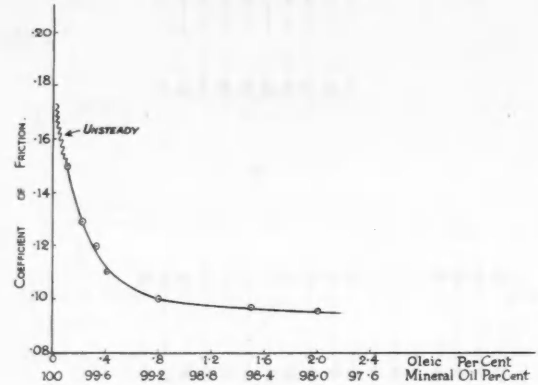

FIG. 7.—Graph showing effect, on kinetic friction, of addition of minute amounts of oleic acid to mineral oil.

gathered by a study of pure chemical compounds in a perfectly clean atmosphere at temperatures at which the compounds remain stable and unchanged and the friction measured is that which just causes slip, i.e. the static friction.

Friction and Heat

It remains to inquire how far these conclusions apply to friction in the kinetic state. Experiments under the latter conditions are rather complicated by the tendency for fluid films to form when the lubrication is no longer strictly "boundary", as we shall see later. It has already been pointed out that, however perfectly polished, two solid surfaces only touch on a few high spots, the area of which may be less than one ten-thousandth of the apparent area, and as the total load is carried on this very small surface the intensity of pressure at these points is very high.

Bowden found that at the moment of slip there is a sharp local temperature rise when a metallic surface is caused to slide over another. For example, for constantan (an alloy containing 40% nickel and 60% copper) sliding on steel the local temperature may rise as high as 600°F., even when the metals are flooded by oil and the average temperature is quite cold. Incidentally the chemicals forming a match head will not ignite until exposed to a temperature over 400°F., yet it is an everyday experience that a match can be raised to this temperature and fired by the friction resulting from rubbing it on a piece of sand paper or even by rubbing it on a sheet of smooth glass.

Smooth Glass

It had been noticed that when a slider was pulled across a plane surface the motion was sometimes "rocky" in the presence of a poor lubricant. To study this further Bowden designed an apparatus whereby one friction surface was held in a device for measuring frictional stress very delicately while the other was very slowly pushed along; the variation in friction with time was recorded by a high-speed moving film camera. When dry or lubricated with inert non-polar oils the motion was found to be discontinuous, sliding proceeding in a series of jerks (Fig. 8a); the surfaces appear to cling together until the rising stress causes a slip, thus relieving the tension and so on. Upon applying the temperature measuring device to this apparatus, each slip was seen to be accompanied by a momentary flash (Fig. 8b).

It is concluded that during sliding little metallic bridges are formed by the cohesion or welding of the high spots, and the stress required to break these down is the friction. It should be noted, however, that when the lubricant was an oil containing a polar fatty acid these discontinuities could not be recognised, the motion proceeding smoothly. At low speeds similar oiliness effects are observed as in static friction tests, and Amontons' law is obeyed; but under certain conditions, notably at high speed, there is some discrepancy between kinetic and static friction, Amontons' law not being applicable. Kinetic boundary experiments are difficult to carry out owing to the tendency for a fluid film to form between fast-moving surfaces. On

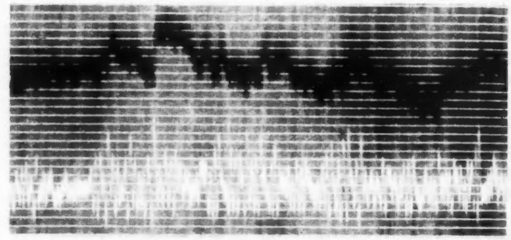

FIG. 8*a*.—Fluctuating friction: steel on steel.

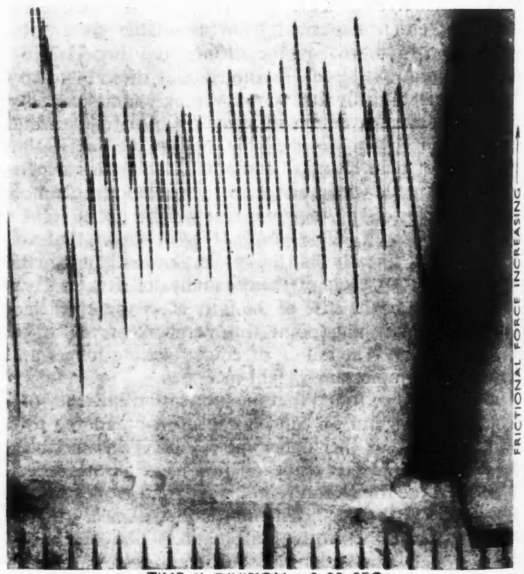

FIG. 8*b*.—The fluctuating friction (1) and the fluctuating surface temperature (2) between steel and constantan surfaces. (*Reproduced from Lubrication Report of the Institution of Mechanical Engineers, 1937*).

the other hand, high-speed tests in a true boundary state are generally accompanied by a certain amount of "tracking" or tearing of the surfaces, and Bowden expresses the opinion that during sliding not only the surface atoms or molecules are concerned but disturbances deep into the mass of the metal must be recognised.

In certain conditions of extremely high pressure, such as occur sometimes between gear teeth, the surfaces tear each other when lubricated by pure mineral oils; but the introduction into the oil of certain compounds of sulphur, chlorine or phosphorus permits the high spots to be smoothly polished off and the tearing effect prevented. Such oils have been called Extreme Pressure Lubricants, and they appear to act by forming sulphide, chloride or phosphide compounds with the metallic high spots, thus behaving as anti-weld fluxes.

Before concluding this brief survey of lubrication by "boundary" films it is necessary to point out that in general practice all bearings are designed to run as far as possible in a totally different state of lubrication known as Fluid Film. In this case the rotation of a shaft in its bearing causes a thick film of oil to form, which completely separates the metals and eliminates solid contact. To build up this dynamic film the surfaces must be so designed that a wedge-shaped layer of oil can form between them, and this is achieved in a plain cylindrical bearing by a certain eccentricity of the shaft when rotating in its bearing due to the "clearance" and the viscosity of the lubricant.

The fluid film is formed by the motion of the shaft, and its thickness depends on the speed for any given viscosity of the oil and load on the bearing. Most mechanical devices operate in this so-called state of Perfect Lubrication when running at the designed speed and load, but under circumstances where the three factors viscosity, speed and load are not suitably correlated the fluid film can become so attenuated that the solids come within range of their force fields, when they involve boundary lubrication phenomena which call for those special properties of the oil which have just been discussed, if wear and tear or even seizure are to be avoided.

Science and The British Council

A GREAT expansion of the activities of the Science Department of the British Council is disclosed in the report of the British Council for 1943-1944. The Science Department, which was formed comparatively recently under the direction of Mr. J. G. Crowther, is to-day one of the British Council's most vigorous branches. The report records that during the year a number of British scientists undertook lecture tours abroad; for instance, Sir William Bragg visited Sweden and Sir John Russell went to Portugal and Spain. Outstanding among the scientific missions undertaken on behalf of the British Council is that headed by Dr. Joseph Needham. Since his arrival in China in 1943 Dr. Needham has visited more than a hundred research institutes and factories, and established links between such bodies as the Chinese Ministry of Health and Britain's Medical Research, and the Chinese Ministry of Economics and Natural Resources and the Department of Scientific and Industrial Research. The supply of essential chemicals and apparatus to China is urgently necessary for the continuation and development of pure scientific research, practical class work and for fine scientific production (for example, the production of vitamins, drugs, vaccines, and microscopes). A Scientific Supply Service has now been organised so that the essential needs of Chinese research institutions, many of them engaged on war work, may be met; this service is limited only by the transport facilities available; so far some twenty-five consignments of material have reached Chungking, to the benefit of seventy-seven institutions. Dr. Dorothy Needham, who is a biochemist, has joined her husband out there. Dr. L. E. R. Picken, a research fellow of Jesus College, Cambridge is due to join Dr. Needham, who has enlisted the services of Professor William Band, the physicist whose escape from Japanese-occupied territory was recorded recently in DISCOVERY (March, 1944).

Monthly Science News, the now-familiar newsletter produced by the Science Department, is issued in English, Arabic, French, Portuguese and Spanish, the total circulation being 55,000. In Sweden an edition of *Monthly Science News* is printed under the editorship of Professor Gunnar Dahlberg. The "Science in Britain" series of booklets sponsored by the British Council and published in English, Spanish and Portuguese has been continued with *The Steam Turbine and other Inventions of Sir Charles Parsons* (by R. H. Parsons), *The Royal Observatory, Greenwich* (the Astronomer Royal), *A History of X-ray Analysis* (Sir Lawrence Bragg), *James Watt and the Industrial Revolution* (H. W. Dickinson and H. P. Vowles) and *S. Z. de Ferranti* (W. L. Randell).

In the medical field the monthly *British Medical Bulletin* is published in English, Spanish, Portuguese and Turkey; in all its circulation amounts to well over 6000 copies. In exchange for this and other material sent out by the Council large numbers of overseas medical journals are received which are passed to suitable British medical libraries. Visits of foreign doctors to Britain have been arranged, and the British Council was jointly responsible with the Medical Research Council for the sending of a delegation of British, American and Canadian surgeons to Russia.

The Engineering Department has been actively engaged with the appointment of overseas advisers, professors and lecturers in engineering and science for Turkey, Egypt, Palestine, Iraq, China and the Latin American countries, from which have been received requests for candidates to fill some thirty appointments. Mention is made in the report of the Federation of British Industries' scheme, to which the Council makes a substantial contribution, for bringing trained engineers to this country from China for practical work, while a scheme for bringing five Chinese pharmaceutical students with scholarships from five different firms is being planned. Similarly Imperial Chemical Industries is providing the funds from which the British Council will bring three Turkish students over here as scholars during the 1944-5 session.

Scientific Research in Scotland

ROBERT H. S. ROBERTSON, M.A., F.G.S.

THE place of scientific research in Scotland cannot be fairly considered except in relation to the needs of the people, the raw materials which can be obtained within the country and those which have to be imported, and the condition of industry as a whole.

After a period of moderate diversification of industry beginning in the eighteenth century, when the printing, textile and tobacco trades began, a great industrial belt was developed on the coal-fields and by the Clyde. This led to an over-specialisation in the heavy industries, which are always the first to feel the effects of a trade depression. These industries were particularly dependent upon the export trade, much of which has been irretrievably lost through the industrial growth of other countries. Unemployment was therefore much greater than in the South where there was a higher proportion of modern light industries, mostly the children of research.

The Chemical Industry

The chemical industry has shown remarkable changes of fortune. Scotland once possessed at Prestonpans the largest sulphuric acid works, and later at St. Rollox the largest chemical works in the world. Many old established chemical firms failed to keep pace with the times by doing research and development work; they were all too often bought up and closed by their bigger and more progressive southern competitors. Attention to research has enabled a few chemical firms to survive in Scotland; alkaloids and chrome salts come to mind. On the other hand, a good example of Scottish research and enterprise, the Cassel Cyanide Co., which, even as late as 1922, was the largest producer of cyanide, was closed down under a rationalising scheme and its activities transferred to England.

The Imperial Chemical Industries, Ltd., have, however, two very large chemical research groups in Scotland. At Grangemouth, research into dyestuffs continues the work so splendidly begun by Morton; here it was that the famous Monastral Blue and related pigments were discovered and first made. Extensive research is now being done there on drugs. At Stevenston, the research has always been mainly applied to explosives, though other products have received attention. The general picture, then, is that the chemical industry in Scotland shows too high a degree of specialisation, and is on too small a scale.

One of the distressing effects of over-specialisation is that when many products have to be bought from England the buyer has to rely for technical information concerning them on pamphlets or the advice given by an agent resident in Scotland. The agent is often non-technical and has to refer back to the head office or to the laboratories in England. In research and development work the flow of new ideas is blocked by this arrangement. Progress is always far more rapid and sure if the chemists of the producing and consuming firms can meet to discuss the problem in hand. Not only are Scottish firms slow to collaborate in this way for fear of losing their secrets, but they do not make a wide enough range of chemicals to make this healthy interchange of knowledge a frequent occurrence.

The soap and paint industries started well, but many firms have been bought by English or American combines and have been closed or turned into distributive centres for the products from over the border. The calico printing works at Thornliebank were closed "in order that Lancashire may be better able to meet foreign competition". Birmingham has recently tried hard to prevent aluminium hollow-ware from being made in Scotland. Even Great Britain as a whole suffered in much the same way when it was found impracticable to develop synthetic rubber in this country. In a short while we realised that Britain possessed practically no chemical engineers having experience of this or similar industries. The U.S.A. soon had a great advantage over us.

Attempts to attract New Industries

Scotland's proportion of the gross industrial production of Great Britain fell from 9·9% in 1924 to 8·2% in 1935; this decline is even more apparent when it is realised that between 1932 and 1937, 3217 factories were opened in England and Wales, but only 127 were opened in Scotland. In the same period, however, 133 Scottish factories closed down.

For some years before the war attempts were made to improve the balance of industry, not by assisting research into new products, but by building trading estates in the hope of "attracting" industry to Scotland. The Scottish Economic Committee, the Scottish Development Council, the Special Areas Reconstruction Association, The Hillington Industrial Estate, mostly sponsored by industrialists, and the Government's special areas schemes all took a hand in trying to attract new light industries. The results were disappointing.

The position to-day is complicated. The Government's policy of dispersal has resulted in the starting up of branch factories of many light industrial firms in Scotland; most of their research and development work is done in England. They may stay in Scotland after the war to take advantage of the cheap but very skilful labour, and to reduce transport costs on their northern sales, but others are known to look forward to concentrating again on their English factories. Some of the firms which are likely to remain have renamed their northern branch the "Scottish —— Co., Ltd.", but the fact is that these are not Scottish enterprises and employ fewer research workers than one would like to see.

Since 1942 some 5000 new industrial enterprises or extensions or adaptations of existing factories, plant or production have been authorised in Scotland. About £11,000,000 have been spent by the Supply Departments on buildings and plant in Scotland. It is of interest that in the last few years several hundreds of refugees have set up new light industries in Britain. South Wales and Northern Ireland especially have given these valuable immigrants facilities to set up small factories, but only 3½% of these new industries have settled in Scotland.

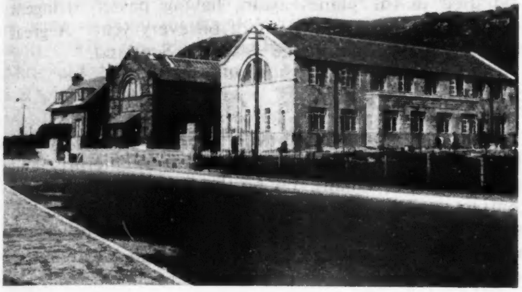

FIG. 1.—The Marine Station, Millport, Isle of Cumbrae, where agar was first made from seaweed.

FIG. 2.—The Macaulay Institute for Soil Research, Aberdeen, famous for its spectrographic work.

National Research

Fortunately the survey of research in Scotland is not altogether a gloomy picture, for in the field of national research there are several world-famous institutions, which specialise in things in which Scotland has a particular interest. For example, Scotland possesses a quarter of the arable land in Britain: it is therefore gratifying to know that there are many institutions devoted to agricultural research in Scotland.

The Macaulay Institute for Soil Research in Aberdeen undertakes advisory work, soil fertility investigations, experiments on soil organic matter and peat, spectrographic work, lysimeter studies, and soil classification and surveys. The Agricultural Colleges in Edinburgh, Glasgow and Aberdeen, the University Agricultural and Veterinary Departments, the Royal (Dick) Veterinary College in Edinburgh, and the Glasgow Veterinary College are all engaged in research in their particular spheres. In addition there are the Rowett Research Institute, Aberdeen, (which houses the Bureau of Animal Nutrition,) the Hannah Dairy Research Institute in Ayrshire the Bureau of Animal Breeding and Genetics, Edinburgh, and the Scottish Society for Research in Plant Breeding, Edinburgh, the aim of which is to promote research for the improvement of crop plants in Scotland. Research in animal diseases is carried out by the Animal Diseases Research Association whose headquarters are at the Moredun Institute, Gilmerton, Midlothian.

The fishing industry is served mainly by the D.S.I.R. Fish Research Station and by the Fisheries Laboratory of the Scottish Home Department, which are both at Torry, Aberdeen. Even before the war disappointment was often expressed at the time-lag between the discovery of new processes for the refrigeration, transport and the storage of fish, and their application in industry. The Fisheries Laboratory has done useful work on haddock and herring fisheries in particular. In view of the great importance of this industry to Scotland, it is a pity that more research work is not done on the fisheries of the West Coast. Fish farming experiments have been started, however, at Loch Sween. The Marine Biological Station at Millport, Isle of Cumbrae, covers a wider and more academic field of study, though its successful manufacture of agar from the red seaweed *Gigartina* had led to the development of a new industry and the safeguarding of supplies of this vital material. There is great scope for research into oyster farming and seaweed culture, especially of the red seaweeds. Cefoil, Ltd., are carrying out research into the extraction and utilisation of alginates from brown seaweeds in Scotland.

There is a local laboratory of the Fuel Research Station for the physical and chemical survey of the National Coal Resources in Glasgow, but the total amount of research on Scotland's greatest mineral asset is quite inadequate. The Scottish Development Council did a great deal of research into oil shales, cannels and torbanites. Although the results were most promising, nothing was done to develop these resources.

Need for Research into Raw Materials

Unfortunately, the raw materials in which Scotland is relatively rich are not usually given the attention which their importance or potentialities should command. There is no Forestry Research Station, though there are University Departments of Forestry at Edinburgh and Aberdeen, and the Forestry Commission through its office in Edinburgh maintains a Research Officer, who with the aid of skilled technical assistants does a large amount of research and experimental work on both nursery and forest sites. On the soil side, the Macaulay Institute works closely with this Department. Nevertheless, it cannot be denied that forestry research needs greatly strengthening in Scotland.

The relatively great hydro-electric resources of Scotland would warrant a Hydro-electric Research Institute. What is needed is research into the uses of electricity in the Highlands in relation to the local raw materials and the needs of the people. One might suggest the electrical de-watering and peat and diatomite, the dialytic extraction of potassium from felspar, the electrostatic separation of

talc, kyanite, antigorite, chromite, and other minerals found in Scotland, and the development of mineral industries which might use electricity for normal or fine-grinding, and so on. The eradication of bracken by means of calcium cyanamide and manganous sulphate is worth a full-scale trial.

This brings us to one of the greatest research needs of all—research and development of raw materials in general, not only by organised fundamental geochemical research, but by research and development work carrying on the work of the Geological Survey, which has published so many war-time pamphlets on the mineral resources of Scotland. The question arises, can Scottish industry do the necessary research and development work and eventually pioneer new processes that would tap new sources of wealth in Scotland?

One of the effects of a bad balance of industry is that many specialist research workers are scarcely to be found in the country at all. They will have to be trained. Even in existing industries there has been a tendency to underpay scientists. Recently, for instance, a B.Sc.(Hons.) graduate was offered a post as a Research Metallurgist at £180 a year. Good posts were few in the Scottish chemical industry and only a small proportion of science graduates remained in their own country. Only 10% of engineering graduates found work at home. While freedom to go to work where one pleases is an axiom of democracy, the new nomadism forced on too many of a country's best technicians by economic necessity or by Government control can only in the long run break up the stability of the community and civilisation itself.

Research and Development

Before the war at least, too many qualified chemists were employed doing control or routine work, and too few on small-scale or development work, for which there was a marked lack of enterprise in many firms. It would appear that scientific workers in Scotland have been slow to organise themselves, as they form only 5% of the membership of the Association of Scientific Workers. However, the present number of Scottish members of the Institute of Chemistry is 10·1% of the U.K. membership, and therefore only a little below the proportion one would expect from a comparison of the populations. It was not therefore surprising to find that Scottish firms took this proportion of samples of a well-known technical raw material from England; nor that the orders which followed were in a much smaller proportion. The industrial managements were not apparently making full use of the chemists' work. However, when a really new substance with many possible applications comes on to the market the Scottish inquisitiveness is remarkably much less. Similarly, membership of specialist or new scientific societies is very low in Scotland. For example, there are only two members of the British Rheologists' Club in Scotland, both recently arrived from England.

On the other hand, within the last two years, spectrometer and absorptiometer panels have been formed in Scotland; these meet from time to time to discuss laboratory methods, applications, results, and details of the apparatus. There appear to be no such organisations south of the Border.

An example of failure to make use of the results of applied scientific research is the fact that no firm in Scotland regenerates used lubricating oil. In England many firms take in used oil, subject it to chemical and physical refining processes, and return it to the user as good as new oil. Used aircraft lubricating oil is treated and used in the planes again, having passed stringent tests and saving tanker-loads of oil every year. A great deal of valuable oil must be wasted in Scotland.

Signs of Awakening

The war has brought new life to Scottish industry, but it has not infected all firms with a spirit of enterprise and enthusiasm. Too many rely on the Government for their contracts and pray for continued control after the war, and make no effort to pioneer new development through the medium of their own research or through collaborative research. There are others, on the other hand, who are beginning to realise that they have to stand on their feet and to co-operate. Recently the Scottish Seaweed Research Association was formed, in addition to a Scottish Slate Quarries' Association and an association of limestone quarry owners in the West of Scotland; and various other groups are coming together, expressing the desire for research to be carried out on the materials in which they are interested. But there is still a danger of the results of research being frustrated by sectional interests, as when an Agricultural Society opposed artificial insemination partly because it would lead to a loss of stud fees.

A new branch of the Institute of Fuel had very successful meetings last winter, and a branch of the Institute of Physics has been formed. An association of Dairy Chemists is in process of formation. On a larger scale, Glasgow Corporation's post-war planning committee is considering the formation of a municipal department of industrial research to attract industry to the district.

The Imperial Chemical Industries, Ltd., has offered 16 out of their 80 research fellowships to Scotland, a generous proportion, but for social reasons it may be argued that it would have been better to allocate some of them to Aberdeen and St. Andrews as well as to Edinburgh and Glasgow Universities. The Scottish Council on Industry has worked hard to create a demand for research in Scotland, but they rely too much on advisory panels.

Need for Co-ordinating Industrial Research

It is not suggested that a country's whole prosperity should be derived from its agriculture, fishing, electric resources, or mineral and non-mineral raw materials, but there is a real danger in neglecting them as they have been in the past, or in relying on imported enterprise giving Scots workers employment in industries making only slight use of the natural resources. In a previous paper[1] I have suggested that Scotland needs a new type of Research Institute, connected with the Department of Scientific and Industrial Research, and devoted to Raw Material Development. The Department would co-ordinate every stage from survey and analysis to small-scale development and production. It would carry out

[1] Chemical Research on Development in Scotland, Scottish Reconstruction Committee, Bulletin No. 3, March, 1944.

within its walls all experimental work which other organisations, Government or industrial, are not equipped to carry out. It would serve as a development branch of the Geological Survey and could do all its analytical work —for the Survey in Scotland has at present no analyst. The Government should have the power to develop new industries to the production stage and then to see that they are democratically managed in the best interests of the country. The new department would also serve as an additional training institution for the staff who would be developing the new processes. Those who were suitable and who wished to do so could eventually run the new processes. The Department would be large and costly, but far more efficient than the very meagre facilities that exist to-day for getting research work done in Scotland.

In China, the National Resources Commission, besides actually working minerals and processes, provides schools, baths, etc., and sets a good example to private enterprise. In the United States, the Federal Government inaugurated the Tennessee Valley Authority, and co-ordinated every aspect of planning from survey to production, the whole vast scheme was carried out with the co-operation of local authorities and the people themselves. The condition of the Central Belt of Scotland and of the Highlands calls for colossal measures of great boldness and vision, quite beyond the powers of competing individuals: it calls for co-ordinated planning, not the piece-meal development of one thing after another. A new research institution would be essential to any such enlightened planning.

Some Post-War Needs for Research

The main subjects for new research might very well start with housing materials, to find Scottish sources of materials for use in paints and varnishes, light-weight aggregates, cement, thermal insulation, hard boards, glass, fittings, flooring materials, bricks, tiles, slates and so on. A recent article in *Nature*[2] admits that Scottish resources have been neglected, but does not see why investigation and development could not be undertaken as part of the general national research effort, or why, for example, separate Scottish Research into housing is required. The answer is that Scotland is being threatened with thousands of Portal houses, almost wholly made in England: Scotland needs new industries and has the resources upon which new industries could be built. The climatic conditions are different and better insulation is needed. Research would show if it is possible to produce insulating materials from peat or expanded clays. The national research stations are too remote to be fully effective, and they seldom employ Scottish scientific workers in their own country.

On the 6th June, 1944, Mr. Leslie asked in the House whether, in view of the urgent need for Scottish light industries and new housing materials, he would set up an experimental research station in Scotland for studying the processing and utilisation of Scottish raw materials, such as seaweed, peat, clays, shales, dolomite, felspar, and diatomite, and the use of hydro-electricity in connexion with raw material development.

Mr. Westwood replied that the Government are fully aware of the importance of industrial research, and as regards Scottish natural resources, the Scottish Council on Industry are in close touch with the Department of Scientific and Industrial Research and other research and commercial establishments. The Council are also in consultation with the North of Scotland Hydro-Electric Board, and have appointed a special committee to investigate what capacity exists or can be developed to produce the materials and fittings for the post-war building programme in Scotland. Also the Council have recently appointed a panel of experts to advise them on scientific and technical questions generally.

This answer shows the fearful inadequacy of the Government's plans for research into Scottish raw materials. No amount of advisory work will ever be a substitute for scientific experiments. A continuous programme of research is needed to develop new processes and materials—research which may sometimes take years. In our present state of knowledge only a few uses of Scottish raw materials can be recommended by the experts, however distinguished they may be, but there is no doubt whatever that properly conducted scientific work would unfold a rich variety of products of real value to the community.

Sir William Y. Darling, chairman of the Scottish Council on Industry, said in July, that investigations were being made into the use of such natural resources as felspar, flagstones, dolomite, silica, limestone, seaweed, and slates, but the fruits of these investigations will be very disappointing unless they are continuously experimented on in a well-equipped and well-financed laboratory. The Council also congratulates itself on bringing to the notice of an oil company a deposit of oil shale in Ross-shire, though nothing has been done about the complex utilisation of far more extensive and wonderfully rich oil-shales and other related rocks in the Lothians.

It is not suggested that all new industries should use native raw materials, but I am convinced of the great danger of neglecting them. If this Research Laboratory were set up, priority could be given to housing materials, as well as to uses of electricity in raw materials development, such as the classification and purification of non-metallic minerals, the extraction of potash from the felspar, the removal of water from peat, diatomite and so on.

A new Research Department of this kind could be part of a larger institution in which all kinds of inventions could be investigated, and in which some of the 26 Trade Research Associations could, if they desired, maintain a Scottish branch fairly economically. An attempt was once made to carry on research collectively in the Scottish leather trade, but the project fell through for lack of guidance. Yet the work of the research association in London is not so easy to utilise because personal contacts are infrequent, and they would be more effective than written reports. If the new Department were run with enthusiasm, it might help to create the greater diversification of industry which is recognised by the Government as important, even in the Scottish region, and it might help to develop a pioneering spirit of enterprise in Scotland, now sadly lacking, a spirit of co-operation and a social purpose in place of exaggerated individualism which has led in the past to such disastrous results.

[2] See *Nature*, 12 August, 1944.

The National Income

OR WHERE DOES THE MONEY COME FROM?

H. W. SINGER, Ph.D.

ECONOMIC science has shown an increasing tendency in recent years to use the concept of the National Income as a starting point and focus of introductory analysis. This has a number of advantages. As compared with the approach to economics through some more abstract concept, such as utility, welfare, etc., economics is made more concrete and more interesting to the average citizen. It is brought into more immediate relation to the actual problems of our day. It has also been made more useful to state administration, as evidenced by the issue of an annual White Paper at Budget time classifying and measuring the National Income in its various components. As we shall see, the analysis of the National Income itself can be conveniently used for the exposition of some basic economic truths and the explosion of some basic economic fallacies. Moreover, by using a basic concept which is immediately capable of verification and statistical measurement from the very start it is brought home to the student, as to the general reader, that economics is essentially a science based on statistics and quantitative measurement, and not an accumulation of "empty boxes" (even though empty boxes have their important uses in economics because they often induce us to look for the stuff to fill them with.)* Finally, the National Income approach also has the advantage of linking economics again in a closer way with its classical beginnings. There is in fact a striking similarity between Adam Smith's approach through *The Wealth of Nations* and the modern approach through the National Income.

The wealth of a country is measured by the level of its net National Income. The net National Income is the flow of goods and services available during the year, after allowance has been made for passing on the instruments of production in the same state of good repair and efficiency in which they had been found at the beginning of the year. The net National Income, therefore, is available in its entirety either for immediate consumption or for additions to the capital instruments of the country. The proportions in which the net income is to be allocated between these two purposes may be decided either by private individuals or by a state planning body; but this is immaterial for our present purpose.

It is important to distinguish between wealth in the sense of a high net National Income and wealth in the sense of a large stock of capital, including investments abroad. There is, of course, a close relationship between the two in that a large stock of capital or investments abroad usually is the result of a high level of net income in preceding years from which part has been detached and used for capital accumulation. Thus a large stock of capital, at home or abroad, usually may be taken as *evidence of* a high National Income. Also, a large stock of capital yields income which is added to the net flow of goods and services. Thus, in addition to being *evidence of* a high National Income, a large stock of capital also is a main *source of* a high National Income. But it is not identical with a high National Income. National capital which is unutilised does not add to the National Income at all. It may have a capital value to its owners, but this capital value must be based on the assumption that the capital asset will be utilised at some later stage when it will add to the National Income. It has, therefore, an anticipatory income value. But in the year for which we measure the National Income the asset makes no difference. The year, of course, is a purely conventional period chosen because most of the relevant statistics, such as income tax statistics, are based on a yearly period, even though this year may not always coincide with the calendar year. Similarly, investments abroad may not add to the National Income if no interest is due (in the case of a long-term development loan, or in the case of shares in companies which do not pay a dividend) or if the foreign debtors default on the debt. It is conceivable, though not likely, that a country may have a large stock of capital and yet a low National Income, or *vice versa*. In actual fact, however, we observe a close correlation between capital per head and income per head. The two are conceptually different though practically related.

National Income and National Output

Is the National Income identical with the national output? This is true with two important qualifications. The first qualification relates to the difference already mentioned above between the gross flow of goods and services and the net flow. The net National Income is the gross flow of goods or gross National Income *minus* an allowance for depreciation and wear and tear of instruments of production. In normal times, the maintenance of the instruments of production is the first charge on the flow of goods and services and is therefore deducted right from the beginning. All the same, it is always possible for a community to *consume* its full output and refuse—deliberately or otherwise—to replace the instruments of production. This process of reducing the National Capital (or "Domestic Disinvestment" as it is called in the jargon of economists and Government White Papers) is usually resorted to in times of war (deliberately) or in times of deep depression (involuntarily). The possession of a large stock of capital thus gives a country a dual advantage: first, a high net National Income, and, second, an opportunity to add to its net income in times of emergency by the gradual using-up of its real capital. This is closely analogous to the case of the private individual on whom private capital confers the dual advantage of an income from it and the opportunity of liquidating it in times of need. This is why an individual with a capital asset yielding him a safe and steady £500 p.a. is

* The best-known of the modern textbooks which enable the "intelligent citizen" to approach economics along this new avenue is the one by Professor J. R. Hicks: *The Social Framework*.

better off than an individual with a safe and steady job at £500 p.a. This second advantage of a large stock of capital, that it can be used up in times of emergency has been shown, in this war, to confer an enormous advantage on the heavily industrialised countries over the merely populous ones.

The first qualification, then, for the identification of the National Income with the National Output, is that the identity holds for the gross income, but not for the net income, except in primitive communities which have no capital stock to maintain or renew. The second qualification relates to international dealings. For the world as a whole, and also for an isolated community (whether it be a country, region or locality), our equation of output and gross income holds absolutely. For a country with international trade connections, however, the goods available in the home market evidently are not necessarily limited by home output, as they can be supplemented by imports from abroad. On the other hand, exports which are sent abroad are part of the National Output (unless previously existing capital assets are exported) but they are not available for home consumption. Thus, our basic equation:

$$\text{Income} = \text{(Gross) Output}$$

now becomes:

$$\text{Income} = \text{(Gross) Output} + \text{Imports} - \text{Exports}.$$

This is a very interesting equation. To begin with, it brings out one of the basic truths about foreign trade. Imports are essentially a good thing because they add to the National Income. Exports, except in so far as they encourage and pay for imports, are essentially a bad thing because they reduce standards of living below the level of output. Now the *value* of exports and imports must be equal in the normal case unless a country obtains credit facilities from abroad or gives credit to other countries. In the case of such a discrepancy due to credit transactions, there will be a corresponding addition to or depletion of the foreign capital, to set against the temporary deficiency or surplus of gross income over national output. If the excess of imports over exports, however, is the result, not of a *new* credit transaction, but the result of *past* credit transactions, i.e. the proceeds from previous investment abroad, it represents a genuine surplus of the National Income over and above National Output. Thus, Great Britain in the years immediately before the war was able to enjoy a National Income which was some £200,000,000 p.a. in excess of the national output. These £200,000,000 represented the proceeds from foreign investment.

"Terms of Trade" and the National Income

Normally, however, if there are no past or present credit transactions the *value* of exports and imports of a country will balance; and therefore the *money value* of its gross income will always be equal to the *money value* of its own national output. The *real contents* of its National Income, however, as distinct from its money value, will clearly increase if in return for a given quantity of exports an increased quantity of imports is obtained, and it will decrease in the opposite case. The ratio of exchange in the foreign trade of a country is thus one of the determinants of a country's real income or standard of living. The cheaper imports are relatively to exports, the higher the standard of living, *with a given level of output and a given value of foreign trade*. This important determinant, i.e. the ratio of exchange in foreign trade, is called in economic terminology the "Terms of Trade".

This again has an important application to the case of Great Britain between the two wars. The Terms of Trade, as just defined, had a tendency to improve considerably during that period as time went on. Between 1924 and 1936 the average price of imports into Great Britain fell by 38·5% while the average price of exports fell only by 31·4%. This indicates a considerable change in the terms of trade in England's favour. It enabled the country to achieve a higher standard of living *at a given level of output*. This last qualification is important because there are a number of economists who maintain that the improved terms of trade reduced the total volume of output and exports sufficiently to offset any benefits from improved terms of trade, by the unemployment created primarily in the export industries and secondarily in home industries as well. This proposition, however, is far from proved. We must not forget that cheap food imported from abroad caused a release of purchasing power for such things as motor cars, holidays, new houses, etc., and that the increased output of industries catering for these wants certainly had a good deal to do with the change in the terms of trade. Perhaps the best way of putting it is not that the favourable change in the terms of trade really was a bad thing, but that we failed to utilise all the potential benefits of this favourable change by wasting some of them in involuntary leisure.

Internal Prices and the National Income

Another economic truth immediately evident from the previous equation is that domestic price changes, i.e. changes affecting only goods which enter neither into exports nor into imports, will not directly affect standards of living in the country as a whole, except in so far as they have indirect repercussions on the level of output as a whole. In their immediate effect, changes in relative prices affect the *distribution* of the National Income rather than its *size*. Thus, if the cobbler gets higher prices for his shoe repairs or pays less for the leather he needs, that in itself neither increases nor diminishes the National Income. Economic activities whose only effect it is to change domestic price relations, such as advertising goods in order to be able to establish higher prices for them, do not add to the National Income and are therefore unproductive. Similarly, cleverness in bargaining, e.g. in finding out weak sellers and beating them down in price, is not a productive activity. Such activities may of course be productive in their indirect repercussions. A weak seller beaten down in price may increase his productive efficiency in order to be able to keep going at that lower price. In that case we may say that the manipulation of domestic prices has been indirectly productive but the increase in productivity is due to the larger output and not to the change in price. Our general case remains unaffected.

Changes in *international* price relations, however, immediately affect standards of living of the country concerned. A favourable change in the terms of trade may be called productive from the point of view of the country

benefiting, although it is unproductive for the world as a whole, except for possible productive repercussions. Skilled bargaining in international trade is a productive asset for a country whereas skilled bargaining in domestic trade usually is not.

Another crude fallacy which can be exposed without much difficulty from our equation is that a rise in export prices will benefit a country even if it is accompanied by an equivalent rise in import prices. This fallacy is inherent in some crude schemes based on the raising of international prices all round in order to assure a "fair return" to either participant. It should be clear that the raising of world prices in general for all goods entering international trade will not benefit a country if the underlying ratio of prices remains the same. Such a change will of course benefit producers of export goods at the expense of other producers and of consumers. Presented in that light it seems clear that such schemes are a plea of certain vested interests rather than a project designed to promote international (or even national) welfare.

Volume of Foreign Trade and the National Income

Let us now sum up the results we have reached at this stage of our argument. A country's standard of living can now be said to be determined by two factors:

(1) the level of national output,
(2) terms of trade with other countries.

It is important to recognise that foreign trade also enters into the level of output, not so much the *terms* of trade but the *volume* of foreign trade. A large volume of foreign trade means that a country can specialise heavily on its export industries, i.e. on those industries in which returns are presumably higher than in other industries for which the country is less suited. We must therefore be on our guard, and not be too pre-occupied with the terms of trade and thus neglect the volume of trade. A large volume of foreign trade on unfavourable terms of trade may be preferable to a small volume on favourable terms, *at a given level of employment*. Schemes which are based on improvement of terms of trade at the expense of its volume ought to be very critically examined, even from a purely national point of view. A high volume of foreign trade has again been shown in this war to be an important factor in economic war strength. Here lies one of the main advantages which England has over Germany. While Germany has to obtain most of her food by domestic agriculture, England obtains her food by exporting industrial goods. The second method is more efficient in an industrialised country. The first method amounts to a self-imposed blockade.

Variety and Complexity of our Problem

Having now reduced the determinants of a country's standard of living to these two, level of output and terms of trade, we must not feel that we have done very much. We have "explained" nothing; we have only labelled. Each of these two determinants conceals a complex variety of individual factors. National output is determined by such factors as: technical knowledge, skill, general education, degree of specialisation, mechanisation, quality of industrial organisation, industrial relations, health, age distribution, scale of production, working hours, volume of foreign trade, to name but a few of the more important ones. Similarly, terms of trade are determined by demand and supply conditions of the commodities entering into foreign trade, the bargaining strength of various countries, monetary conditions in each country, the exchange rate system, multilateral or bilateral nature of trade, and so on. We can see that we have reached the threshold of economic analysis, but by no means its end.

Money and the National Income

What now has money to do with the National Income? Money enters the National Income in three ways, which it is important to keep apart:

(1) Money is the common measure of all things economic; this enables us to add them up through their prices. In the real sense, the National Income consists of a vast collection of heterogeneous things, from coal to barbers' services, from bulldozers to ice-cream (pre-war). This collection of goods would leave us completely bewildered and incapable of grasping its magnitude, let alone the changes in its magnitude, if it were not for that common measure of money value which enables us to add up a ton of coal, the services of a barber over a year, a bulldozer and a hundred ice-creams. Money values enable us, by an ingenious trick, to add up the non-addable.

Not that the use of this yardstick is without its drawbacks. To begin with, we have to exclude all transactions which have no equivalent in money. Services of housewives, food grown on allotments, work done by people in their leisure time for their own enjoyment, all these and others cannot be fitted into our National Income calculations. This divides our National Income from true economic welfare. As Professor Pigou once pointed out, the National Income would be enormously increased by a general "swopping" of wives among neighbours, Mrs. A. working as a paid housekeeper to Mr. B., and *vice versa*. These drawbacks are regrettable but not fatal. In normal times they will not affect a comparison unduly, although they may in abnormal times like war. They must also be borne in mind in international comparisons, especially between agricultural communities with self-sufficient farms and industrialised countries. The National Income statistics have a tendency to underestimate the income of countries like India, Yugoslavia, or even Germany, relatively to a country like England, for the reason mentioned above.

The second major drawback in using money as a yardstick is not so serious as it appears at first sight. By accepting money prices we tend to inflate the value of the output of those industries where price is inflated by restrictive and monopolistic practices—unless, of course, we save our face by including the effects of restriction among the "cost" of producing. This, however, is a piece of mental acrobatics which many people would find difficult to perform. Conversely, the value of goods produced on a non-profit making basis, such as state services of many kinds, tends to be correspondingly underrated. This difficulty is not serious in the measure

ment of *total* output since we have invented an ingenious way to get rid of money again after it has fulfilled its purpose of adding up the non-addable. This we do by the use of a *price index*. This again is not without its drawbacks, but is nevertheless a handy and indispensable tool for the economist. Monopolistic practices will thus increase the money value of output over and above what it would otherwise be *at the same level of output*. But it will also raise the price level in a corresponding degree. As we obtain real incomes by correcting money incomes according to changes in price levels, such practices will therefore not make a difference to our measurement of real incomes. In international comparisons, too, any mistake arising from differences between the ratio of prices to cost can be eliminated by the use of a proper exchange rate between the two currencies.

(2) Apart from being a common measure of addition, money also is a great social invention which raises levels of output. In the absence of money, i.e. with economic barter, economic exchange and division of labour could never have been carried to anything like the stage it has reached in many countries. Our present level of output is entirely based on exchange and specialisation. Money is thus much more than a mere yardstick. It is the indispensable pre-condition for the achievement of a high real income.

(3) Changes in the amount of money, caused by monetary policy, have very important repercussions on the general level of output. These repercussions are important enough to form the main subject of a whole separate branch of economic science. Generally speaking, an increase in the amount of money, by raising prices and increasing profits, tends to have a stimulating effect on production in general and the demand for investment goods in particular, and tends to produce an increase in real output. Similarly, periods of falling prices tend to be associated with a fall in the real volume of production. Needless to say, changes in monetary policy also have a considerable bearing on the terms of trade and the volume of foreign trade.

Is the National Income, then, equal to the sum total of the money incomes of the individuals forming the economic community? The answer is, roughly yes, but so roughly that important adjustments have to be made before we can equate the two. The most important adjustment is in respect of the so-called "transfer incomes". Transfer incomes are incomes received without productive services having been rendered, i.e. without a contribution to national output having been made. The line of division of productive incomes and transfer incomes is, of course, somewhat arbitrary. Old age pensions might be called charitable incomes but they might also be called deferred pay for work performed by people at an earlier stage of their lives. Unemployment pay might be called a transfer income, but it might also be called payment for the services of an unemployed person, rendered by keeping himself fit and available for future work if and when required. Even persons in receipt of pure charity might be said to render the giver the service of enjoying his own magnificent generosity. It has become a convention among economists to classify as transfer incomes to be deducted from the sum total of personal incomes all incomes not provided in return for a specific contribution separately assessed in terms of money values. This, of course, is logical, in view of the close link between money transactions and the measurement of the National Income.

The Wider Significance of this Approach

This article has been far from comprehensive. A wide stretch even of this first approach to economics through the National Income has been left untravelled. In particular, we have not even touched upon the extremely important relation between consumption and capital accumulation which can be very neatly set out by the National Income Approach. Nor have we referred to the close and important bearing of this approach on the present problem of paying for the war and on the future problems of national resources and priorities in post-war Britain. Perhaps enough, however, has been said to show that the National Income approach makes economics less dismal, more useful, and perhaps also more acceptable to the scientific mind.

Glycyrrhizin: Nature's Sweetest Compound

MOST people think of cane sugar as the sweetest compound that occurs naturally. Pride of place must however be given to "glycyrrhizin", the sweet principle of licorice. In the 26th Streatfeild Memorial Lecture to the Royal Institute of Chemistry (now available as a booklet) Dr. P. A. Houseman, dealing with the history, cultivation and chemistry of licorice, states that glycyrrhizin is nearly 50 times as sweet as cane sugar. Its sweetness, which is still detectable at a dilution of 1 part in 20,000 parts of water, is also much more persistent. This substance, to which a satisfactory formula has yet to be allotted, confers upon licorice much of its commercial value. Yet paradoxically the Spanish root, containing not much more than half as much glycyrrhizin as the Oriental types, sometimes commands as much as twice the price of the latter. Spanish root contains about 6 to 8% glycyrrhizin, that from the Near East about 10 to 14%. The reason for this apparent price anomaly is that other factors such as superior flavour come into play.

The licorice plant is a leguminous shrub which grows to a height of several feet. It has bluish flowers. It sends down a tap root and develops a veritable thicket of runners which may be 25 feet long, so that when the root is dug it is not eradicated and enough runners remain to carry on propagation and produce another crop several years later. The part of the plant growing above the ground is devoid of sweetness and has no commercial value.

The preparation of licorice extract is simple in principle, involving grinding of the root, extraction with hot water and evaporation of the solution. By far the greater part of the world's supply of licorice extract is used, not in confectionery, but in tobacco products: smoking tobacco, plug tobacco and snuff to which it has been added do not dry out so readily.

A badger that was brought up as a pet after capture when only a few weeks old.

The Badger

ERIC HARDY, F.Z.S.

Economic biology is not a subject confined to the parasitical habits of minute insects and the studies of our fisheries and forests. Amongst the wild life of our English countryside the scientist, the practical field biologist, the amateur naturalist, have each scope for studying the habits of various creatures in relation to the economy of the national land policy, particularly in war-time. For seventy years legal protection has been afforded to those of our wild British birds whose habits are useful to agriculture. Nothing like that has ever been afforded the wild mammals of our countryside, which are equally useful. In point of fact the major part of the limited legal protection afforded to wild mammals is of ancient lineage from the days when sport dominated the policy of the land, and modern field biology has shown these creatures to possess habits detrimental to agriculture when they are so protected that they increase beyond natural balance. The hare, the rabbit, and the deer receive this sort of uneconomic protection for sport under the Game Laws, and the fox receives unofficial protection with similar uneconomic results. But the continued existence of those mammals whose habits are directly useful to agriculture in war-time depends upon the general knowledge of their habits, which seems to be astonishingly limited. Only the grey seal receives limited legal protection during its brief winter breeding season.

The badger has been the most persecuted of economically useful animals, and in view of the general ignorance of its habits which has led to its persecution in war-time natural history societies and scientific bodies all over the country have been organised to promote the legal protection for this mammal so soon as it is possible to occupy Parliament's time after the war. Their evidence has already induced County War Agricultural Pests Officers, notably for Cumberland, to withdraw the badger from the official list of "vermin" and afford it protection. The badger, it appears, will be the first British wild mammal to be afforded full legal protection on the same basis as that useful on which wild birds are protected.

The badger is not rare in Britain. In the wooded valleys of Wales, Scotland, Lakeland and the Delamere Forest of Cheshire badgers have defied persecution for generations. Here and there generally in England, badgers exist in surprising places: they have had their earths or setts as near London as Richmond Park, Ken Wood and Box Hill, near Dorking, and I've seen them using their earth in Cotterill's Clough nature sanctuary on the outskirts of Manchester. Most of the Yorkshire dales have their badgers, and in Cheshire I counted as many as thirteen earths in the Relic's Moss Wood of Delamere Forest just before the war, when badger-digging was common on the Welsh hills around Dolgelly. It is true that to a large extent the badger is nocturnal and mainly active from midnight to 2 a.m.; and that he is also a winter hibernator. But this is not wholly so, for badgers not infrequently come abroad hunting for rabbits at the warren in mild winter weather, and some years ago I met one—to my extreme surprise—in broad daylight, grunting its way along an allotment garden on the edge of Leicester.

What are the natural and unnatural enemies of the badger in Britain? Foremost, the steel gin-trap set by the

game preservers, either specially for the badger or primarily for fox, rat or rabbit. The badger has a habit like the dog of rolling on objects, and the broad, tough back of the badger frequently springs the trap it rolls upon without affecting the beast. I've had experience of this in Cheshire coverts. The second enemy is the electric railway which the unsuspecting badger crosses on its nightly prowls, especially in winter when badgers roam far from their breeding haunts, those from the Ribble valley coming down to Southport and parts of south-west Lancashire and those from mid-Cheshire down to the Wirral peninsula. Badgers are often discovered for the first time in a district by the finding of their bodies electrocuted on the railway lines. They have been found thus on the electric railways of the Cheshire coast and west Lancashire. Other enemies are poison—in war-time even strychnine—put down by game preservers; digging out the badger with terriers to afford rural sport by baiting the animal; the wholesale felling of woods for timber; and the earthstoppers of the hunts, who destroy the badger because he is apt to scrape open those earths they have blocked up to prevent the fleeing fox making his natural escape below ground.

On the other hand factors favouring preservation of the badger are the extensive re-afforestation plans which afford it fresh haunts in the new pinewoods, its own nocturnal and secretive habits which often enable it to inhabit a district unknown to naturalists nearby, its ability to defend itself against any single dog or other predatory creature, and the abundance of its natural food, the rabbit.

By what observations can the naturalist assess the economic habits of the badger? Its natural food is discovered not only by the identification of food remains in the "setts" or burrows, but by examining the excreta droppings of the animals in their haunts, and by an examination of the dentition of the animal. Mere heresay evidence, so common in countrymen's tales of badgers' misdeeds, are seldom substantiated sufficiently to prove that the misdeeds were not those of fox, or stoat, and certainly they cannot be used for generalising. The dentition shows the badger to be a carnivore, like its near relatives the mustelids, but like the bears it also has many vegetarian and particularly wild fruit-eating habits. The observation of pet badgers in captivity shows their fondness for blackberries and wild fruits. From time to time the field naturalist or gamekeeper who is observant and interested may find scrapes in the soil or turf which might indicate root feeding, except that they most frequently occur under cow and horse dung, which indicate rather feeding on grubs. In Cumberland the badger has been observed in daylight persistently turning over the dried flaits of cow dung in the pastures and eating the dung beetles discovered beneath. He also examines carrion for the grubs. Ears of corn are sometimes noted to be bitten off and eaten whole, but this must be only by way of tit-bits, for examination of the badger's droppings shows that the grain is not digested. Examination of the collected droppings of badgers found that 98·2% of the remains were of insects and small rodents, and only 0·2% were eggshells.

The main food of the badger appears to be grubs, especially large ones like those of the wasps, for the excavation of whose nests the badger is proverbially notorious. He will also scrape out the grubs and honeycombs of humble bees, and will eat beetles, small rodents such as young rabbits, young rats and field-mice and occasionally old rabbits, ground-nesting birds, hedgehogs, slugs and snails, frogs and probably roots of wild plants, acorns and beechmast. The badger, like the fox, the polecat, and the stoat, forms a natural brake upon the increase of the rabbit in the countryside, and the persecution and extermination of these animals from certain districts is a direct contribution to the destructive and abnormal increase of rabbits. From the economic point of view we must choose between harbouring rabbits, hares and pheasants, all of which destroy crops and are uneconomic in the countryside, or having badgers and fewer rabbits.

Adult badgers are abroad oftenest and longest in June and July, but when they are suspicious of watchers at the "sett" they may come out only for an hour, or not at all. In summer they may lay up in long grass or undergrowth without going to earth. A practice of theirs soon after they leave the burrow in the night is to scratch or sharpen their claws upon a nearby tree trunk, much as one's cat does this in the garden, and very often the badgers have their favourite tree for this purpose. The next practice is generally to rub themselves vigorously against the tree like a sow in a sty: perhaps this is testimony to the fact that Mr. Russell's notes in his book on the flea, that badger and man are the only two animals to share the same species of flea, *Pulex irritans*!

In autumn, when the badger is pig-fat from its feeding, boar or sow weigh anything up to 40 lb., a weight probably exceeded only by the grey seal amongst British carnivores, although the otter comes near to it. In life this creature is amongst the longer-lived animals, with a possible age of about twenty years.

The breeding habits of the badger are extremely interesting, for like those of the otter they are somewhat spasmodic and the breeding season is somewhat irregular. The gestation period is surprisingly long. Although many conflicting statements appear in natural history literature, badgers will probably mate in autumn or as late as December—I have even heard the weird scream of the sow badger that is associated with the mating season in early winter—and the cubs are born early in May. The cubs leave the "sett" for the final time about the end of July, usually being driven away by their parents. Pink or fawn-coloured badgers are occasionally seen, for albinism and partial albinism are not very rare with this mammal: it shares this trait with the mole, the black rat and the fallow deer, and it seems to be encouraged by inbreeding through lack of fresh blood locally. It is true that badgers and foxes sometimes share the same earth, but not on the intimate terms recounted in some natural histories. Most reports originate from a fox occupying a vacated badger's earth, or both keeping to their own separate compartments of a much-branched earth. In the latter case observation of the footprints often shows the badger and the fox to use different entrances, or the badger to leave immediately upon the vixen's arrival. In winter badgers will leave a district for about a month, wandering far and then returning early in spring for an orgy of excavating and cleaning out the old earths, relining with bedding ready for the birth of their young carried so long.

Night Sky in November

M. DAVIDSON, D.Sc., F.R.A.S.

The Moon.—New moon occurs on November 15d. 22h. 29m., U.T., and full moon on November 30d. 00h. 52m. The following conjunctions take place:

November			
5d. 00h.	Saturn in conjunction with the moon	Saturn	0·1°N.
10d. 18h.	Jupiter ,,	Jupiter	4 S.
17d. 05h.	Mercury ,,	Mercury	5 S.
19d. 02h.	Venus ,,	Venus	3 S.

The Planets.—Mercury rises after the sun during the month and sets very shortly after the sun at the beginning and middle of the month. On November 30 the planet sets about 50 minutes after the sun. Venus can be seen in the evening; her times of setting at the beginning, middle and end of the month are 17h. 45m., 18h. 12m., and 18h. 18m. respectively. Mars is too close to the sun to be observed. Jupiter, in the constellation of Virgo, rises at 2h. 19m. and 0h. 48m. at the beginning and end of the month, and on these dates the planet is respectively 560 and 523 million miles from the earth.

Saturn can be seen close to ζ Geminorum during the month. The planet sets just after midnight at the beginning of November, and at 11h. 12m. and 10h. 11m. at the middle and end of the month. Its distance from the earth decreases from 793 to 760 million miles from November 1 to November 30. Those who wish to search for Uranus will find it close to τ Tauri.

Times of rising and setting of the sun and moon are given below, the latitude of Greenwich being assumed:

November	Sunrise	Sunset
1	6h. 53m.	16h. 33m.
15	7h. 17m.	16h. 11m.
30	7h. 42m.	15h. 55m.

November	Moonrise	Moonset
1	17h. 28m.	7h. 38m.
15	6h. 27m.	16h. 26m.
30	16h. 38m.	7h. 49m.

The Leonid and Andromedid meteor showers are due in November, the former on November 13 to 14, and the latter on November 17 to 26. For several years these showers, once very active, have been weak or non-existent, and it is not very probable that they will supply many meteors this year.

JUNIOR SCIENCE

Jet Propulsion

THE way jet propulsion works can be illustrated by an extremely simple experiment. Just attach a piece of rubber tube (some old gas tubing is excellent for the purpose) to a water tap and turn on the tap. At first the bit of tube seems to try and lift itself up and then, when you turn on the water more, it begins to dance around and to throw water in all directions. So you'd better make the experiment over a large sink! If you hold the nozzle of the tube in your hand and point it downward you will feel that there is a force acting in the direction opposite to the stream of water as soon as you open the tap. Now, where does this force come from and how does it act? To answer these questions, attach a rigid pipe (glass or metal, whatever you can find) with a hole in it to the tap by means of a short length of rubber tube (Fig. 1). When the water is turned on, the pipe will be pushed in the direction opposite to the hole from which a jet of water is squirting (Fig. 2). This is the explanation: The water presses equally against all parts of the pipe; that means the same force is exerted on every square millimetre of the inner wall of the pipe, except at the place of the hole, for since there is no wall the water has nothing to push against and flows out. Thus the force exerted by the water is unequally distributed. It is greater on that side of the pipe which is intact than on the side with the hole. The result is that the pipe is driven out of its original position by a force opposite to the jet. Since it is only the pressure of the water that counts, the experiment would work as well with a jet passing into a vacuum as with our jet that passes into air. It is the force which the water exerts on the opposite wall and not, as people sometimes think, the force against the surrounding air that matters. The jet does not push *away* from anything. You can prove this by holding a board just behind the jet (Fig. 3); it will not push the pipe further away. The jet planes about which you have heard so much work very much like your water jet, only that instead of water a stream of air of high pressure is shot out.

K.M.

FIG 1.

FIG. 2.

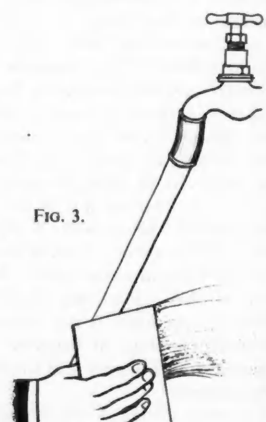

FIG. 3.

The Bookshelf

Geology in the Service of Man. By W. G. Fearnsides and O. M. B. Bulman. pp. 158. (Pelican Books, 1944; 9*d*.).

DURING the last fifteen years the vitally important study of the relation of science to social needs has made great progress. But the study of geology in this connection and the public appreciation of geology has lagged behind. This little book is, therefore, important. In the first 80 pages the authors have attempted the difficult task of presenting a compressed account of geology termed, "The Nature of the Evidence: An Introduction to Geology". Fifty years ago this would have been unnecessary, but then the book would have been written for a much smaller circle of readers. To-day the great majority of well-educated people, and even of scientists, would require to study the first part of this book before they could appreciate the second. One could take exception to the allocation of space in the first part. It was a mistake to devote pages 5-8 to a very compressed discussion of the crystallisation of a magma, a difficult subject by no means essential to the purpose of the book. There are several statements which will probably draw upon the authors the wrath of specialists, but this is of small importance compared with the general success of the attempt to get some understanding of geology across to 50,000 readers. In the 80 pages of the second part the authors deal with topics such as water supply, soils, engineering problems and supplies of petroleum and of minerals. One of the examples is the problem of the construction of the Mersey tunnel, which is very well done, although one could have wished for a sketch map and a section as illustrations. But these are minor criticisms, and the authors deserve the credit for starting the job of creating a wide understanding of the part which geology can play, not only in Britain, but in the development of the enormous area of the Empire. N.F.M.H.

Aristotle: Generation of Animals, with an English translation by A. L. Peck, M.A., Ph.D., pp. lxxviii, + 608. (The Loeb Classical Library, Harvard University Press, London: Heineman, 1943. 10*s*.).

ARISTOTLE: *Generation of Animals* is of all his treatises on the natural sciences perhaps the most instructive and illuminating, more especially for those who are interested in the history of science and the development of the scientific mode of thought. Here, in fact, as Dr. Peck points out, Aristotle's thought is to be seen integrated as it is nowhere else. This claim is made good in an admirably lucid introduction in which the translator not only has analysed the Aristotelian philosophical and scientific concepts but also has placed them in their due perspective in relation to earlier Greek and modern scientific thought. Text and translation are fully annotated. E.N.F.

The Chemistry of Life. An Easy Outline of Biochemistry. By J. S. D. Bacon. (Watts & Co., Ltd., Thinker's Library No. 103; pp. x + 118; 2*s*. 6*d*.).

LIKE so many writings on the subject of biochemistry, this book is prefaced with a tribute to Sir F. G. Hopkins. The author is one of his more recent pupils and this effort of his to interpret the chemistry of living things to the layman is one of which Sir Frederick will undoubtedly approve.

Dr. Bacon has shown the imagination and understanding required in writing for the non-technical reader. He demands that the reader should have an elementary understanding of chemical fundamentals such as are usually known to the older students in secondary schools. This and a little everyday biology, combined with the use of his glossary of technical terms, is sufficient to take the intelligent student through the complete argument.

The critic seeking important omissions is likely to be disappointed. The main trends of biochemical investigation are all discussed. Important examples of practical and philosophical applications of their results are given with interesting and up-to-date details. The methods of experimental approach so far applied in this field are described in simple terms and their achievements and limitations reviewed.

The non-specialist reader will be struck by the immense practical importance of biochemists' discoveries. They have resulted in revolutionary changes particularly in the important field of nutrition. The description of the biochemistry of food and feeding is a most noteworthy aspect of the book.

Some experts have, often with justification, expressed their fear of the populariser. They need have no such fears in connection with this book.

It is written in the light of a wide and up-to-date knowledge of the subject, sets its matter in a correct perspective and expresses a sober but optimistic judgment.
A.R.T.

The Impact and Value of Science. By Douglas W. Hill, D.Sc. pp. 88. (London: Hutchinson; 7*s*. 6*d*.).

THIS is certainly one of the most irritating books on the social relations of science that have ever appeared. As may be expected, it achieves in most cases a perfectly sound statement as to *what* the modern problems of the impact of science on the community are, but when it comes to discussing solutions, the author is naive and rhetorical by turns, and cannot be said to achieve much progress.

For example: six pages are devoted to a chapter on "The Scientific Outlook", but most of them are taken up with a singularly unfruitful attempt to draw a distinction between science and technology. On "Science and Industry" Dr. Hill achieves a higher level, although he lands himself in a number of inconsistencies with the previous chapter. Here Dr. Hill is least effective of all when he attempts a discussion of such evils as slums and unemployment on an exclusively moral basis. He seems to think that these can satisfactorily be accounted for as the result of selfishness on the part of industrialists, and that if industry were under the control of scientists, such a change alone would be sufficient to allow effective "unselfish" administration.

The same line of altruistic thinking pervades his discussion of "Science and Politics". For Dr. Hill, politics means detailed political machinery, never political theory. His case for creating a government of scientists hardly gets much support from his own naive attacks on political parties and "ignorant politicians". He does not at any point seem to realise that the form of government creates the necessity for parties to render it workable: that policies of which large sections of the community disapprove are not pursued by politicians out of ignorance—far from it—but because those politicians represent the interests of other sections of the public.

So it goes on. The chapters on "Science and Education," "Science and Religion" and "Science and Leadership" are all frankly second-rate. In all of them rhetoric is substituted for insight, and vague generalisations for clear thinking. The dust jacket says "Dr. Hill has been both an industrial and an academic scientist . . . who has lived abroad in Hitlerite Germany as well as in the U.S.A. and in England, where he has had practical experience as an administrator in the Civil Service". This career is reflected in the book: it is impossible not to recognise that something is gravely wrong, but Dr. Hill has not faced the fact that it is in the world in which he has made his own career that the greatest changes seem most needed if a lasting reconstruction is to be secured. D.S.E.

A Game Warden among his Charges. By Lieut.-Col. C. R. S. Pitman (Penguin Books, 1943; pp. 192; 9*d*.).

THIS re-issue in cheap and popular form of Colonel Pitman's account of certain of the fauna under his charge as Game Warden of the great Uganda game-reserve comes at a particularly opportune moment. From every side the needs of future post-war development are being urged ceaselessly upon a somewhat bedazzled public.

No one for whom wild life has any attraction can fail to read this fascinating account of the great game of East Africa —the white rhinoceros, the hippopotamus, the elephant, the mountain gorilla, the crocodile, the hyena and the leopard—to name a few only of the more striking—and not feel that their extinction would be an irreparable loss even in a post-war Utopia. E.N.F.

Far and Near

Sulphonamides and Cerebro-spinal Fever

THE cure of cerebro-spinal fever by the administration of drugs belonging to the sulphonamide group is still one of the most striking achievements to the credit of chemotherapy. The importance of this relatively recent advance in medical science emerges clearly from the statistics provided in the Department of Health for Scotland report entitled *Sulphonamides in the Treatment of Meningococcal Meningitis* (Stationery Office, 4*d*.). The report is the outcome of a survey which originated in 1940. It was then evident that an exceptionally large epidemic of cerebrospinal fever was occurring in Great Britain, and the Infectious Diseases Sub-Committee of the Scientific Advisory Committee to the Department of Health for Scotland considered that the opportunity presented itself for a detailed assessment of the recent history of the disease in Scotland, especially in view of the advances in treatment that had been made. The decision was made that every case from the beginning of 1936 to the end of 1941 admitted into the infectious disease hospitals of Edinburgh, Glasgow, Dundee, Aberdeen City and Lanark County should be included in the survey. The report is based on the study of 2223 cases, representing about 40% of all cases notified in Scotland during the period 1936-41; the population of the areas directly served by these hospitals is about 45% of the population of Scotland. The average fatality rate for the total of 2223 patients was 21·86%; the total number of patients who were treated with sulphonamides only was 1762, and among these the fatality rate was 16·68%. A fatality rate of 51·76% was recorded for 199 cases receiving serum or antitoxin but no sulphonamide. With sulphonamide treatment between 70 and 80% of the cases were clinically cured within a period of four weeks. The report comments that, although the sulphonamides seem equally effective when given during any part of the first week of illness, institution of treatment should nevertheless be prompt. A comparison between the three main drugs—sulphanilamide, sulphapyridine and sulphathiazole—does not suggest that any one possesses clear advantages over the others.

Cure for Colds Still Needed

THE hope that patulin might prove an effective cure for the common cold has been dispelled with the publication in the *Lancet* (1944, **247**, p. 370 and p. 373) of results obtained in large-scale trials of the drug carried out in a number of factories and in the British Army. Preliminary trials made in 1943 gave a figure of 57% of colds cured in 48 hours when patulin was administered as a nasal spray, as against 9·4% recovery in "controls" who received no dose. (DISCOVERY, 1943, **4**, p. 382). No demonstrable effect, however, was shown in the tests made under the auspices of the War Office; these indicated that patulin is bacteriostatic to a wide range of bacteria, both gram-positive and gram-negative. On injection into experimental animals, the drug appeared to have considerable toxicity, a feature exhibited by several mould-derived drugs on sharp contradistinction to penicillin. From the results of further tests, for which workers of eleven factories and three Post Office units volunteered, the Patulin Clinical Trials Committee set up by the Medical Research Council concludes that there is no evidence that patulin is effective in the treatment of the common cold.

Storing Iron in the Body

DISCOVERY of a new type of protein which acts as the storage depot for iron used by the human body to form hæmoglobin, the red blood pigment, was announced at the 108th meeting of the American Chemical Society held last month in New York. The new findings, reported by Dr. Leonor Michaelis and F. Granick of the Rockefeller Institute for Medical Research, explain part of the mystery of iron metabolism in the body. The pure protein, without its iron, was named apoferritin. It takes on and stores iron for the blood pigment, and in this form is known as ferritin. The iron in ferritin is not found in the crystallised protein as a well-defined iron salt but in the form of ultra-microscopically small granules or micelles of iron hydroxide, interspersed in the crystal lattice of the protein molecules.

A brown-coloured, ill-defined protein with a high iron content was first described 50 years ago, Drs. Michaelis and Granick state, and in 1935 a Czech scientist, Lauffberger, discovered this iron compound could be crystalised as a pure compound in the form of its cadmium salt. This protein contained as much as 20% of iron. The Rockefeller Institute scientists followed up this work and discovered that by a special device all the iron can be withdrawn from this compound, and the iron-free protein can be crystallised again, this time being colourless but otherwise indistinguishable from the brown, iron-containing crystals. They named the brown crystals ferritin, and the colourless protein apoferritin. The crystal form of ferritins varies slightly in different animals. Specific immunological reactions reveal that the ferritin of one animal species is not quite identical with that of another, but that for any particular species this protein is the same whether derived from liver, spleen, bone marrow, or other organs. No ferritin or apoferritin can be found in the blood.

Every iron compound has a characteristic magnetic property or "magnetic susceptibility." When an iron salt containing the iron in the form of its radioactive isotope is injected into an animal, its passage in the body can be studied by means of its radio-activity. It is then found that the iron is rapidly stored up in the liver, or under certain conditions also in the spleen, in the form of ferritin which is now radioactive. The apoferritin seems to provide a way of storing the iron introduced either from the food or from the decay of the blood-iron, and to make it available for synthesis of fresh blood pigment.

Peeling Potatoes with a Chemical

PEELING of fruit and vegetables in large quantities has long been made easier by a process of immersion in caustic soda. For example, peaches are skinned by this method before canning. During the war the technique has been employed on an even larger scale than before and, according to a paper by A. H. Copeland, R. M. Chatters and R. D. Kerwin presented to the American Chemical Society, the widespread use of soda lye for this purpose has led to the discovery of new drugs, plastic ingredients and valuable oils from the peels and seeds that were formerly wasted. The world's largest potato-processing plant, situated in Caldwell, Idaho, can peel 450,000 lb. of raw potatoes in a day, the tubers being conveyed through a 20% caustic soda solution which is kept a temperature just below boiling. Three minutes treatment is sufficient to loosen the skins, eyes and surface blemishes, and the potatoes are then conveyed mechanically through a rotating cold-water washer in which they are freed of skins and all caustic soda by means of high-pressure water sprays.

New Species of Potatoes

THE potato collecting expeditions sent out by the Imperial Agricultural Bureaux in 1938-39 to Mexico and South America represented the first attempt within the British Empire to make a thoroughly scientific and exhaustive collection of plant material for the initiation of a large-scale breeding programme. Unlike previous expeditions sent by other countries (for instance the three Russian expeditions that went to South America in 1925 and subsequent years) the members of the British Empire Potato Collecting Expeditions concentrated on the problem of potatoes, no attempt being made to collect samples of food plants in general. This intensive effort enabled a very large and detailed collection of over 1000 specimens to be made. A number of new species and varieties were included in this material. Samples were obtained from the whole length of the Andes mountains, not only in the more populous and easily accessible regions, but also in the wildest places far from human habitation where no earlier expeditions had travelled. The description and classification of these specimens has now been completed and is published by the Imperial Bureau of Plant Breeding and Genetics, Cambridge, under the title of *Potato Collecting Expeditions in Mexico and South America—Systematic Classification of the Collections.* This bulletin, prepared by Dr. J. G. Hawkes, is available from the Imperial Agricultural Bureaux (Central Sales Branch), Agricultural Research Building, Penglais, Aberystwyth,

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price 7*s*. 6*d*. Over half the bulletin is devoted to the taxonomy of the specimens collected by the British Empire expeditions, and in this section are incorporated the results obtained from chromosome counts. The origin and evolution of cultivated potatoes is dealt with in an interesting chapter. This proceeds from Professor N. I. Vavilov's hypothesis that the centre of origin of a crop plant is to be looked for in those regions where the specific and varietal diversity is highest to the suggestion that the cultivated potato must have originated in the Lake Titicaca-Cuzco region of North Bolivia and South Peru. The cultivated potato in Chile, on the other hand, did not exist in a variety of species and Dr. Hawkes considers it unlikely that this country was the centre of origin of potato cultivation. With the appearance of this bulletin the number of potato species is brought up to some 20 cultivated and 150 wild species. Dr. Hawkes remarks that it is probably that so far as the wild species are concerned the wealth of variation lies practically untouched, indeed it is possible that three or four times the quantity of species that we know now has yet to be discovered, from material growing in the more isolated and inaccessible regions of the South American Andes.

Scientific Service of the Royal Navy

LAST month the Admiralty announced the formation of a Royal Naval Scientific Service which will be responsible for meeting the Navy's needs "in the fields of research, experimental design and development". This represents a change of name rather than a new departure as the Scientific Service will be staffed by those now forming the Admiralty Scientific, Technical and Chemical Pools, at present working under the Director of Scientific Research, who will be in charge of the new service. There were some 600 persons in the three pools at the outbreak of war. These groups have been expanded since 1939 and their combined staffs now total about 3500. It is not considered possible to forecast at present what numbers will be be required for permanent service.

A New Cyclotron

SCIENTISTS of the Department of Terrestrial Magnetism at the Carnegie Institution, Washington, have started experiments using a new cyclotron. This is reported to be one of the two largest cyclotrons in operation in the world, the other being at Berkeley, California. The instrument, which generates particles of 15,000,000 electron volts energy, weighs more than 225 tons; it has an overall height of 12 ft., and is 30 ft. long and 20 ft. wide. Its construction took four years to complete.

New Incendiary Bomb

ANOTHER new and devastating incendiary bomb has been added to the armament of our bomber aircraft by the research and scientific workers of the Ministry of Aircraft Production. The new bomb weighs 30 lb. Its main filling consists of a solution of methane in petrol under pressure. Its descent is controlled by a parachute which reduces its terminal velocity. When the bomb is functioned it emits from its tail a jet of flame about 15 ft. long and 2 ft. wide. The length of the bomb is approximately 21 in. Its diameter is 5·5 in. On impact the striker of the bomb fires the detonator. The flash from the detonator ignites the priming in a central tube. The priming ignites the thermite and this heats the interior of the bomb, raising the internal pressure. When the pressure has been raised sufficiently the petrol is forced through the flexible tube into the valve chamber, through the outlet hole in the jet, and through the hole in the bottom of the parachute container. As it passes out of the jet, the petrol is ignited by the flame issuing from the vent holes in the striker housing as a result of the burning thermite. The jet of flame thrown will continue for a period of two minutes.

The bomb is the outcome of long and intensive research by the Ministries of Aircraft Production and Home Security, in conjunction with Leeds University. The production and filling stages were done by Imperial Chemical Industries. The team responsible for the introduction of the bomb includes Professor G. I. Finch, F.R.S., of the Ministry of Home Security; Professor D. T. A. Townend and Dr. E. C. W. Smith, Leeds University; Lieut.-Col. C. J. P. Bateson and Captain A. Hayton Cowap, I.C.I.; S/Ldr. D. R. Ashworth, Ministry of Aircraft Production

Personal Notes

Two Chinese scientists have come to study in Britain as guests of Cambridge colleges and of the British Council. They are PROFESSOR DJANG TSE-KUNG and PROFESSOR YIN HUNG-CHANG. The former, a professor at the Central China University, has been invited to reside at Christ's College, where he will continue his researches in the history of science. Professor Hung-Chang, of the Associated South Western Universities, Kumming, a biochemist who has specialised in the investigation of auxins, has taken up residence at St. John's College.

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After twelve years as Director of the British Non-Ferrous Metals Research Association DR. HAROLD MOORE, C.B.E., is retiring, at the age of 66. He began his career in the Research Department of Woolwich Arsenal, which he joined in 1904 as chief metallurgist. The Great War led to a great development of the Research Department's metallurgical section, its staff increasing in number from four to forty, and Dr. Moore became director of Metallurgical Research. In 1932 he succeeded Dr. R. S. Hutton as director of the British Non-Ferrous Metals Research Association. During the years 1934-36 he was president of the Institute of Metals, which honoured him in 1943 by the award of its Platinum Medal "for outstanding service to non-ferrous metallurgy". Dr. Moore has represented both the Institute of Metals and the Non-Ferrous Metals Research Association on the executive of the Parliamentary and Scientific Committee.

THE following appointments have been made to the staff of Bristol University:

DR. J. E. HARRIS becomes professor of zoology in succession to Professor C. M. Yonge who has gone to Glasgow University as Regius professor of zoology.

DR. WILSON BAKER succeeds Professor E. L. Hirst as Alfred Capper Pass professor of chemistry.

DR. A. G. PUGSLEY succeeds Professor J. F. Baker, who went to Cambridge a year ago, in the chair of civil engineering.

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THE death occurred on August 15 of LIEUT.-COLONEL LEO FRANK GOODWIN, professor of chemical engineering at Queen's University, Kingston, Canada, at the age of 66. During the last 35 years he probably turned out a larger number of fully qualified and successful chemical engineers than were trained in the whole of the rest of the British Empire—Canada excluded.

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PROFESSOR S. P. MERCER, Professor of Agricultural Botany at Queen's University, Belfast, died last month at Carrickfergus, Co. Antrim. In 1919 he was appointed assistant director of the official seed testing station for England and Wales, and in 1922 head of the seed testing and plant disease division, Ministry of Agriculture, Northern Ireland, becoming in 1928 senior technical research officer. In 1919 he married Constance, youngest daughter of the Rev. A. L. Davidson.

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JOHN ARTHUR THORPE DAWSON, B.SC., PH.D., and ROBERT HURST, M.SC., experimental officers of the Ministry of Supply, have received George Medals for highly dangerous research on explosives in the department's laboratories. Before joining the Ministry, Mr. Hurst was demonstrator in the department of chemistry at Canterbury University College, Christchurch, New Zealand, and has also held the post of demonstrator in the department of physical chemistry at Cambridge University.

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SIR JOHN C. G. LEDINGHAM, F.R.S., of Mill Hill, N.W., died, aged 69. Director of Lister Institute, 1931-43. Joined it as assistant bacteriologist in 1905. Member of Medical Research Council, 1934-38. C.M.G. 1918. Knighted 1937.

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Rooks and Their Feeding Habits

IN certain areas throughout the country pests officers of War Agricultural Executive Committees have been asked to shoot from 20-40 rooks a week during the next twelve months. The Edward Grey Institute at Oxford will examine the crops of all the rooks that are shot, and on completion of this "crop survey" it may be possible to give a more definite answer to the question, "Is the rook a beneficial bird?"

Society for Visiting Scientists

ON September 6, a reception was held at the premises of the Society for Visiting Scientists, 5, Old Burlington Street, London, W.1, to mark the inauguration of

the Club House and Information Centre. Professor F. G. Donnan, Emeritus Professor of Chemistry at London University, is president, while the chairman of the honorary council is Field-Marshal Smuts. The two honorary presidents are Sir Malcolm Robertson (Chairman of the British Council) and Sir Henry Dale (President of the Royal Society). The members of the working committee which controls the affairs of the Society, are Professor J. D. Bernal, Dr. J. S. Huxley, Lord Rothschild, Professor P. M. S. Blackett, Dr. J. Cisar (Director of Czechoslovak Research Institute), Professor J. H. de Boer (Professor of Chemistry, University of Utrecht), Dr. D. P. O'Brien (representative of Rockefeller Foundation in Great Britain), Professor A. S. Photiades (Professor of Applied Physics in the Technical University of Athens), Professor S. Pluzanski (Dean of Polish School of Engineering in London), Brigadier B. F. J. Schonland (director Bernard Price Institute of Geophysics at the University of Witwatersrand, Johannesburg), Professor J. Timmermans (Professor of Physical Chemistry and History of Chemistry), Major L. Tronstad (Scientific Adviser to Norwegian High Command), Dr. L. Rapkine, (Director of Research in French National Commission of Scientific Research), Sir H. Spencer Jones, Dr. E. B. Bailey. The secretary to the committee is Mr. J. G. Crowther, director of the Science Department of the British Council.

The small but comfortable Club House and Centre was furnished with the help of Sir Simon Marks and Lord Rothschild, and under the guidance of Mrs. Bernal, Mrs. Blackett and Mrs. Huxley.

At the opening of the Club House, which had been postponed in July owing to the risk from flying bombs, Professor Donnan said: We are fortunate in having with us at the present time many excellent representatives of science from the countries of our Allies and the lands of the British Commonwealth. The very good idea occurred to the British Council to form a Society for the purpose of bringing our visiting scientists together with their English colleagues, and providing them with a Club House where they could all meet together for the exchange of ideas, discussions, lectures, and the consumption in good fellowship of solid and liquid refreshment, and where some modest provision could also be made as regards bedroom accommodation. The Royal Society has given its blessing to this plan. The Society's House will contain a Bureau of Information which will be at the disposal of all visiting scientists for the purpose of advising them concerning British scientific societies and institutions, and helping them to get in touch with British colleagues in their various spheres of work. I think we shall have done something of enduring value if we can hold out to the young wandering scholar-scientists of the future the hand of real help and friendship. Other countries have their own Centre for Visiting Scientists—Belgium has its Fondation Universitaire in Brussels, Germany its Harnack House in Berlin, and Russia its centre in Leningrad.

Mr. Crowther explained that it was hoped to have micro-films of the leading foreign scientific journals which could be examined at the Society's rooms.

The Right to Publish

The secretary of the British Medical Association has sent a letter to voluntary hospitals and local authorities in which he voices a protest by the B.M.A. against the action of certain employing authorities in restricting the publication of scientific material. In the opinion of the Association a doctor, whatever the nature of his employment, should be completely free to publish findings based on his scientific observation and enquiry.

Bogomoletz's Serum

The Empire Rheumatism Council, which has sponsored experiments with the aim of assessing the efficacy, as a rheumatism cure, of the anti-reticular cytotoxic serum developed by Professor Bogomoletz (Discovery, May 1944, p. 160), has issued the following report: Tests which have been possible with the scanty supply that arrived from Russia have not given results which would justify a favourable verdict. The best that can be said is "not proven." Nevertheless, in view of the high reputation of Soviet medical research, it is possible that with a more detailed statement of the optimum methods of employment and some lead as to the type of rheumatic disease for which the serum is best adapted, it may be found that the claim advanced for it can be substantiated. So soon as war conditions in Europe allow, the Empire Rheumatism Council propose either to invite a representative of Professor Bogomoletz to visit England, or to send a research scientist to Russia to make further investigations. Meanwhile the council cannot recommend its use.

A record has been kept of the many patients who have volunteered for tests, and they will be informed individually with grateful acknowledgment of the help they have offered. We hope that sufferers will recognise that war interference with means of communication and transport has imposed special difficulties, and that there has been, and will be, no lack of effort in following up any claim which holds out for them promise of relief.

Storage of Micro-film

With the greatly increased use of micro-film in recent years, problems of its storage are assuming importance. Valuable recommendations dealing with the storage of acetate micro-film, both in roll form and in flat strips of film, are given in British Standard No. 1153-1944, copies of which may be obtained from the Publications Department of the British Standards Institution, 28 Victoria Street, London, S.W.1, price 1*s.*, post free.

Research in Manchester

The first members of the Manchester Joint Research Council which is being formed jointly by the Manchester Chamber of Commerce and the Manchester University have been announced by the Vice-Chancellor of the University (Sir John Stopford) and the president of the Chamber (Mr. A. H. S. Hinchcliffe) as follows:

University representatives: Professor P. M. S. Blackett, Dr. C. J. T. Cronshaw, Professor D. R. Hartree, J. R. Hicks, Professor Willis Jackson, Professor J. Jewkes, Sir William Clare Lees, Dr. E. J. Myers, Professor M. Polanyi, Sir Ernest Simon, Sir John Stopford, Sir Raymond Streat, and Professor F. C. Thompson.

Chamber representatives: Messrs. J. Harold Brown, E. A. Carpenter, J. Curwen, R. H. Dobson, John S. Dodd, M.P.; Dr. A. P. M. Fleming, Messrs. H. M. Harwood, A. H. S. Hinchcliffe, Frank Longworth, L. E. Mather, N. G. McCulloch, Lord Peel, Messrs. C. G. Renold, A. V. Sugden, and John F. West.

After the first meeting which, as already announced, is to be held on October 9, it is proposed that the Joint Council shall meet quarterly. At the first meeting various constitutional matters will be settled. The first chairman will be elected and other members co-opted. In this latter connection, proposals will be tabled to ensure close liaison with the British Cotton Industry Research Association and the Department of Scientific and Industrial Research. Other subjects noted for consideration are a statement of the aims and objects of the Joint Council; election of an executive committee; secretariat; and the establishment of an information bureau.

Scientific Mission from India

An Indian scientific mission is arriving in Britain this month. It is understood that the party will consist of the following: Dr. Nazir Ahmad, Director of the Cotton Technological Laboratory, Matunga, Bombay; Colonel S. L. Bhatia, Deputy Director-General of the Indian Medical Service; Sir Shanti S. Bhatnagar, F.R.S., Director of Scientific and Industrial Research, India; Sir Jnan Chandra Ghosh, Director of the Indian Institute of Science, Bangalore, and President of the National Institute of Sciences of India; Professor S. K. Mitra, of the University College of Science, Calcutta, Chairman of the Radio Committee of the Board of Scientific and Industrial Research; Professor J. N. Mukherjee, Professor of Chemistry at Calcutta University; Professor Megh Nad Saha, F.R.S., of the University College of Science, Calcutta, the eminent physicist. They expect to stay in England for about seven weeks, during which time they will visit important scientific laboratories, and industrial, medical and agricultural research institutions in and near London in the Midlands and North of England and elsewhere in the United Kingdom; they will also discuss modern scientific progress with such bodies as the Royal Society, the Department of Scientific and Industrial Research, the Medical Research Council, the Agricultural Research Council, and the Radio Board.

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